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DEVOTED TO THE CONVERSION, TRANSMISSION and DISTRIBUTION OF ENERGY.

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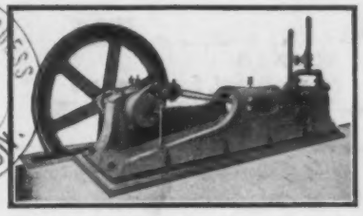

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INDEX TO CONTENTS PAGE VII. CLASSIFIED LIST OF ADVERTISMENTS PAGE XIII. ADVERTISERS INDEX PAGE XVI.

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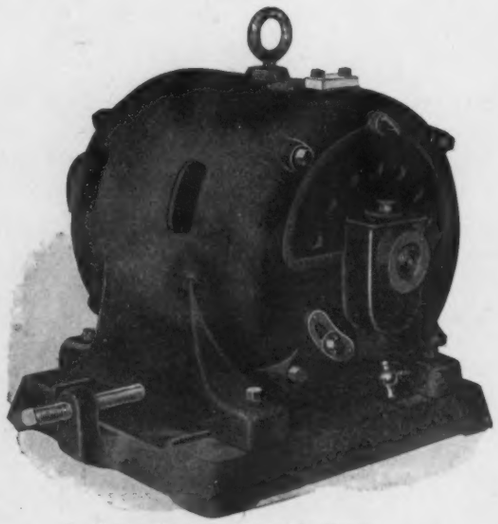

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The Journal of Electricity, Power and Gas.

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VOLUME XV. SAN FRANCISCO, CAL., OCTOBER, 1905. NUMBER 10

Electricity in the Barber Plant of the Diamond Match Company.

BY GEO. P. LOW.

CHICO, County Seat of Butte County, Cal., and distant by rail nearly two hundred miles north of San Francisco, on the Shasta route of the Southern Pacific Company, is probably the most beautiful and progressive city in the northern part of the State. The pursuits of the community are both agricultural and horticultural, for with its vast expanse of contiguous grain fields, its nearby cattle ranges, its wealth of citrous and deciduous fruit groves, it possesses resources which assure its permanent prosperity. It is such a country that The Diamond Match Company, looking ever to the preservation of its investments, has selected for the perpetuation of the great industry it has established, for there it sees and possesses standing timber of the best to last it for generations.

F. M. CLOUGH
Pacific Coast Manager

Whatever is the condition of the public mind in the East, there exists a misconception in the West regarding the business of The Diamond Match Company, as here it is not engaged in the manufacture of matches as yet; rather does it produce the highest grades of white and sugar pine and red fir lumbers, either unfinished or worked-up as may be desired. To speak of the industry as a "match" factory is a misnomer thus far, although early in the coming spring the employes of a new factory that is now being erected will be making matches for Pacific Coast consumption. The forests of the company cover above 70,000 acres of the best timber land in the State, wherein it is estimated that over 2,500,000,000 feet of lumber is standing. At Stirling City it has within the last eighteen months established a community of over 1000 people through the building and operating of a sawmill of a capacity of 200,000 board-feet of lumber per ten-hour day. This mill embraces every refinement known to sawmill practice. The company has built and is operating the Butte County Railroad, a superbly constructed and equipped standard broad gauge steam railway connecting Stirling City with Chico through thirty-two miles of road, and lastly its manufacturing plant at Barber, as is the case with each property of the company, may be cited without reservation as being representative of the best manufacturing practice of today in its every branch.

Barber, the cite of The Diamond Match Company's lumber yards and finishing mills, is located immediately adjoining Chico on the south and but five or six minutes ride by electric car from the center of the city. As is the case at Stirling City, Barber is an unincorporated town. In all, the yards and works of the company occupy 120 acres, of which fifty acres are allotted to the lumber yards, twenty acres to railway terminal facilities and the remainder to manufacturing purposes. The yards have a storage capacity of approximately 50,000,000 cubic feet of lumber, and it is an imposing sight to see its streets and alleys, the latter being practically half a mile in length, forming solid blocks of great piles of lumber that, for its quality and variety, has no superior on earth. This uniformly prevalent tone of pre-eminent superiority exists on every hand, for nowhere has expense been spared in securing the best. All buildings are of the most approved types of mill construction as recommended for their specific uses, the system of fire protection and patrol is as perfect as has been devised, its machinery, methods and processes are typical of most recent practices—in fact lead them in many instances—and in brief, if any improvement can be suggested concerning any feature of the plant the company is not aware of it. The truth of these statements will be evidenced by the article which follows in description of its

power plant: Nowhere else is there an establishment of this character and extent which is driven solely by its own high grade steam-driven electric plant with the exclusive use of electricity for operating each and every machine and appliance. The entire plant is new in every detail, as must follow from the fact that its construction was not begun until eighteen months ago and that milling operations have been under way for but twelve months.

Reverting to the power plant, the building housing it is of brick with massive concrete foundations and floors throughout. It is roofed with corrugated iron supported on angle iron trusses, and between the boiler room and engine room is the sawdust bin consisting of a brick vault eighty-four feet long, twelve feet wide by a height of thirty feet. This bin is really divided into two compartments by an arched passageway that is bricked-in through it in order to afford a means for passing between the boiler and engine rooms. Standard fire doors connect the bins with the boiler room, but no openings exist between the bins and the engine room, as the specifications for a fire wall without openings into the bins are inexorable. Similarly the passageway is closed between the engine room and boiler room by a fire door at its boiler room end. Steam for the operation of the engines is generated by a battery of four Stirling water tube boilers of a rated capacity of 258 horsepower each, and the boiler room is large enough to admit of the installation of two additional boilers of like capacity.

These boilers, which are set singly, have therefore an aggregate capacity of 1032 horsepower, and in each there is 2587 square feet of heating surface and 58.5 of grate surface, the grates being 6′ 6″ deep. Each boiler has three steam drums 36″ x 12′ 8¼″, and one mud drum 42″ x 10′ 3″, the tubes being of a diameter of 3¼″, 233 in number and of seamless hot rolled steel. The space occupied by each boiler, including brickwork, is 12′ wide, 16′ deep and 17′ 7$\frac{3}{16}$″ to the top of the steam opening. The brickwork above the foundation required 76,968 red brick, 9720 No. 1 fire brick and an equal number of No. 2 fire brick.

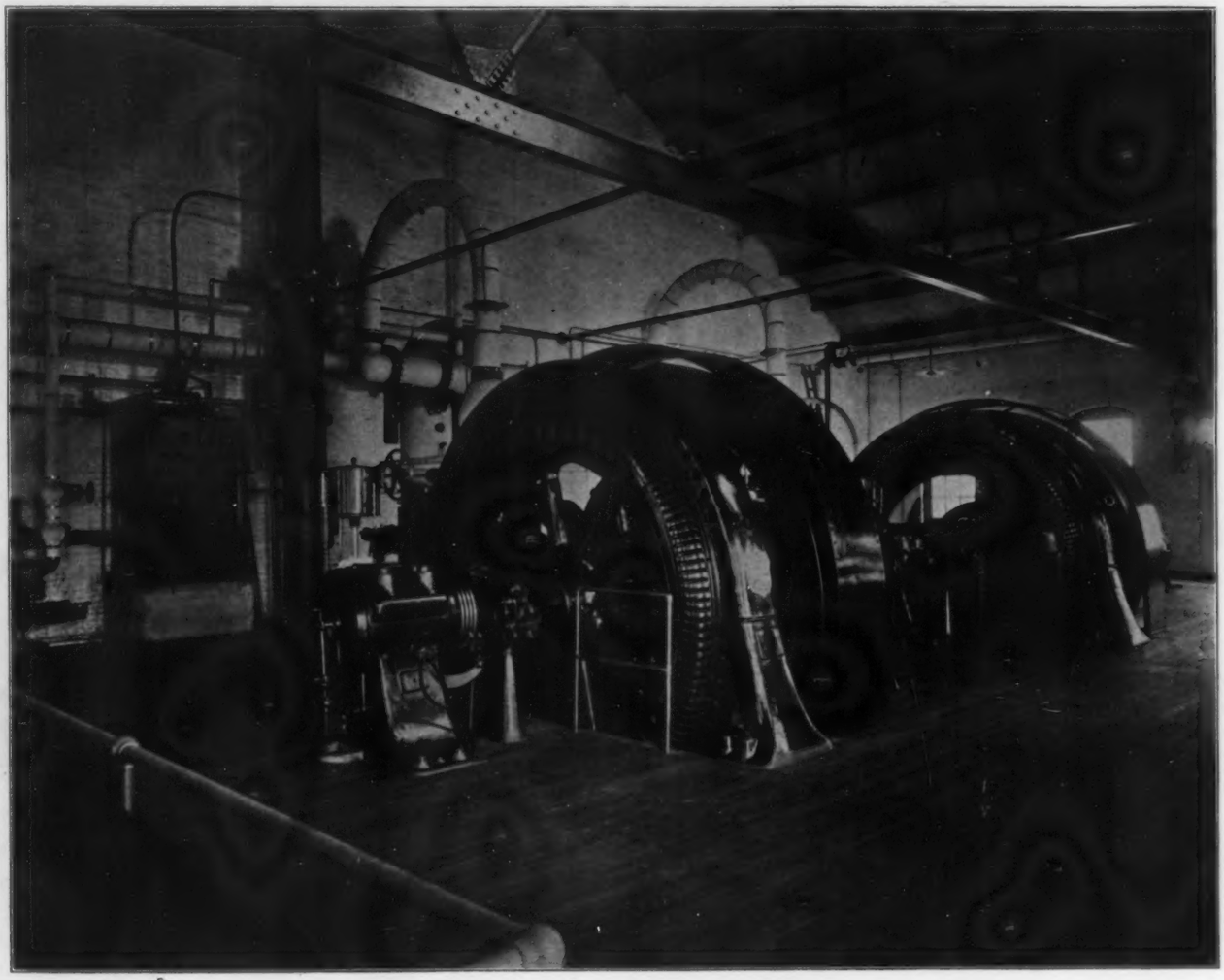
THE ENGINEERING DEPARTMENT OF THE DIAMOND MATCH COMPANY, WITH POWER HOUSE IN THE REAR

The refuse material from the factories is used in firing the boilers, as is more particularly detailed later, and as practically all of this material consists of sawdust, shavings and "hogged" splinters from kiln-dried pine lumber that is fairly rich in resinous substances it forms

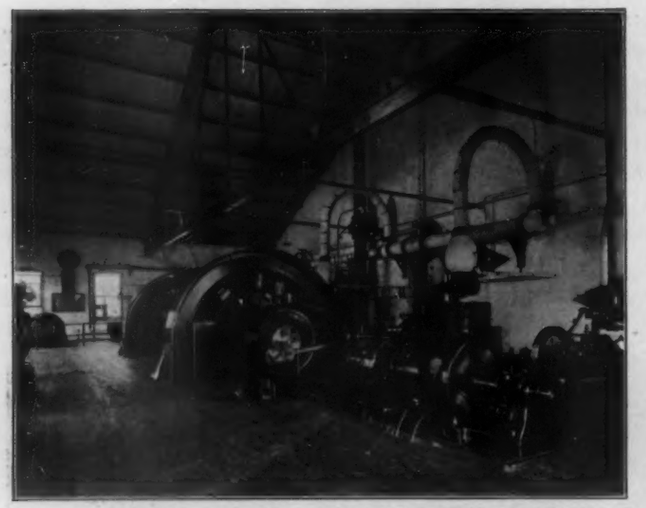
ideal fuel. The method by which the furnaces are fed with this fuel is admirably shown on page 435. It is simple, indeed, in that it consists merely of spouts through which the fuel is blown under the boilers from the blower system. It seems to be the characteristic of all wood working mills of this nature that the superabundance of fuel refuse which is available makes it unnecessary for either the designing or operating engineers of the plant to make any investigation into, or, in fact, to take any material cognizance of, the fuel efficiency of the refuse referred to. There is plenty of it and its commercial value is inconsequential, with the result that no note is taken either of the quantity consumed or of the amount of water that is evaporated for a given quantity of refuse burned. The problem involved is one of getting rid of the refuse rather than that of obtaining the greatest possible efficiency from its fuel value. This is particularly the case with sawmills, but at the Barber plant there is as yet insufficient fuel in the nature of dust and shavings to make all the steam necessary for the operation of the works at all times, with the result that a comparatively small quantity of slab wood is always kept on hand for emergencies. When it is required to burn slab wood, the fuel spouts are raised; but it is rarely necessary to do this. A "dust' burning plant is a fireman's paradise: it is perfectly clean, is sweet smelling, and the fires are most easily kept, as the amount of fuel that is blown under the boilers is regulated by dampers placed in the blower tubes with perfect ease.

The stack, which is a prominent landmark thereabouts, is a beautiful example of steel construction. It is cylindrical in shape, with a diameter throughout of 94" by a height of 150', supported on a flared base with a maximum diameter of 18', the whole resting on a concrete foundation, having a depth of 24'. Upon the latter rests a concrete stack base 25' square and 6' deep, which is battened off to a diameter of 19' at the top. To this base the flared steel base is secured by means of 2" anchored bolts, each 21' 1" in length. The stack, which weighs 90,000 pounds complete with breeching, was built in five sections, as follows:

First section, 18 feet of $\frac{7}{16}$" steel.
Second section, 20 feet of $\frac{3}{8}$" steel.
Third section, 20 feet of $\frac{5}{16}$" steel.
Fourth section, 30 feet of $\frac{1}{4}$" steel.
Fifth section, 62 feet of $\frac{3}{16}$" steel.



THE TWO 400-KILOWATT BULLOCK GENERATORS



INTERIOR OF THE ENGINE AND GENERATOR ROOM OF THE POWER HOUSE OF THE DIAMOND MATCH COMPANY AT BARBER

Water for the operation of the plant, as well as for all purposes about the works, including fire protection, is taken from two wells located on the grounds nearby the power house. One of these wells is eight inches in diameter and 150 feet deep, and the other, which is four inches in diameter, is 192 feet deep. It is excellent steaming water, and is raised to the surface by the air-lift system, whence it is discharged into a 140,000-gallon tank built of concrete, let into the ground near a corner of the engine room. The feed water is taken from this tank by either one or the other of two $\frac{9 \times 5}{10}$ Worthington boiler feed pumps and heated by a Corcoran heater. Two Underwriters fire pumps, each $\frac{18 \times 10}{10}$, of Worthington and Snow manufacture respectively, and each having a capacity of 1000 gallons per minute, also take water from this tank for supplying water to the automatic sprinkler system and the fire plugs which are located at seemingly innumerable points about the premises.

The sturdy character of every feature of the plant is shown on this page, which illustrates the wall of the engine room toward the sawdust bins, and whereon are shown a portion of the steam piping system, which, together with the valves thereon, are of crane manufacture. A single ten-inch Austin steam separator located in the main line serves for the entire plant.

The main engines consist of two McIntosh & Seymour horizontal, single cylinder, side crank engines, supplied with steam at a throttle pressure of 125 pounds per square inch and running at a speed of 150 revolutions per minute. The bore of the cylinder of each engine is twenty-four inches, its stroke is thirty inches and each engine drives a fifteen-inch shaft which supports a 400-kilowatt generator about to be described, as well as a twenty-ton flywheel, upon two bearings each having a length of twenty-two inches by a diameter of twelve inches. The generators are of the revolving field type manufactured by the Bullock works of the Allis-Chalmers Company, at Cincinnati. The frequency of their output is sixty cycles in three-phase current, the full load rating being 400 kilowatts at 440 volts and 525 amperes. Exciting current for the operation of these generators is taken from a motor generator set consisting of a fifty horsepower type "C" induction motor which drives by direct coupling a Bullock direct current generator delivering at full load 375 amperes at 120 volts, the speed being 850 revolutions per minute. In starting up the main plant, it is necessary to first place in operation the small auxiliary plant soon to be described, in order to run the motor-generator set to obtain exciting current, but after the main unit is in operation it takes the motor-generator load and the auxiliary unit is shut down. This auxiliary unit consists of a 13 x 12 Harrisburg side crank self-oiling engine, with outboard bearing supporting a flywheel whence is driven by belting a seventy-five-kilowatt Bullock, three-phase, sixty-cycle, 440-volt generator, running at 900 revolutions per minute, the speed of the engine being 300 revolutions per minute. All night lighting and patrol service is run from the seventy-five-kilowatt set, which entails but slight

A CORNER OF THE ENGINE ROOM, SHOWING IN PARTICULAR THE METHOD OF STEAM PIPE CONSTRUCTION

THE 75-KILOWATT AUXILIARY SET, WITH FIRE PUMPS IN THE BACKGROUND

NORMAL CONDITION OF THE BLOWER PIPES FOR FIRING SAWDUST FUEL

additional expense in its operation, for the reason that steam must be kept up in the boilers at all times in order to supply heat to the drying kilns. All engines were supplied by Messrs. Chas. C. Moore & Co., Engineers, Inc., of San Francisco. The principal remaining piece of machinery in the engine room is a Clayton compressor which furnishes air at a pressure of eighty pounds per square inch for the operation of the air-lift wells and the pneumatic tools in the machine and boiler shops. This compressor is steam driven, with twin cylinders measuring $\frac{8 \times 8}{10}$ in size and running at a speed of 160 revolutions per minute.

The switchboard consists of five panels of blue Vermont marble. Beginning the enumeration at the left, the first panel is devoted to the control of the exciter, for the purpose of which it carries one 125-volt voltmeter, one 300-ampere ammeter, one exciter rheostat and a main 200-ampere, double-pole, single-throw switch connecting with the exciter busbar. This panel carries also on its upper left hand corner a Wagner synchronizer that is mounted on a swinging bracket, while the lower half of the panel is occupied on its front side by a lever for manipulating the main line oil switch supported on its back.

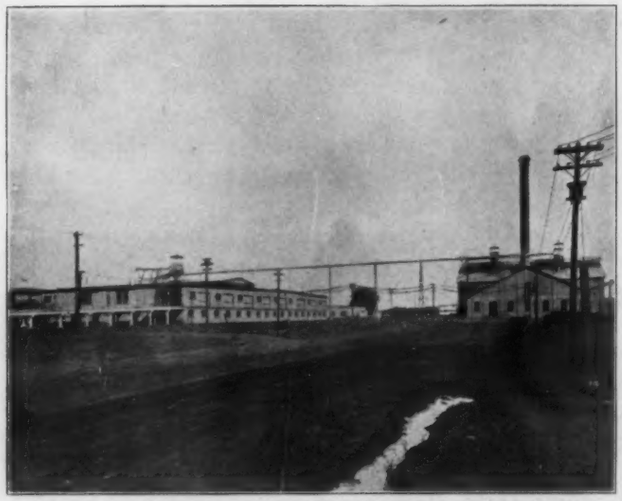
Panel No. 2 is devoted to the seventy-five-kilowatt generator, for the control of which it carries a 600-volt voltmeter and a 140-ampere ammeter, both of the alternating current type, a Cutler-Hammer rheostat, a Carpenter rheostat, a double-pole, single-throw field switch and a triple-pole, double-throw 300-volt, 200-ampere machine switch, so connected that in one position it is used for feeding the station circuits and in the other position for outside service in case of breakdown.

Panels Nos. 3 and 4 are alike, and each is for the control of its respective 400-kilowatt generator. For this purpose each panel contains a 200-ampere direct current ammeter, a 700-ampere alternating current ammeter, a 600-volt alternating current voltmeter, a double-pole, single-throw, field switch, a Cutler-Hammer field rheostat, a triple-pole, single-throw, 400-ampere machine switch, a double-pole, double-throw, 25-ampere switch for the control of the electric governor that is placed on the flywheel of the main engine, beside the usual equipment of synchronizing lamps and plugs.

The feeder circuits go out through panel No. 5, which contains three ammeters each of a capacity of 1400 amperes, four feeder switches each of a capacity of 400 amperes at 500 volts, three of which control the power service and one being for the lighting service, two Thomson recording wattmeters for the respective services (which are independent) and one Thomson 1400-kilowatt wattmeter for recording the total output. On the upper right hand corner of this panel is carried a synchronizer which is mounted similar to that on panel No. 1.

All indicating instruments appearing on the switchboard are of the edgewise type as manufactured by the Wagner Electric and Manufacturing Company. The board is erected some six feet from the station wall,

BLOWER "CYCLONES" OVER THE SAWDUST STORAGE BINS OF THE BOILER HOUSE



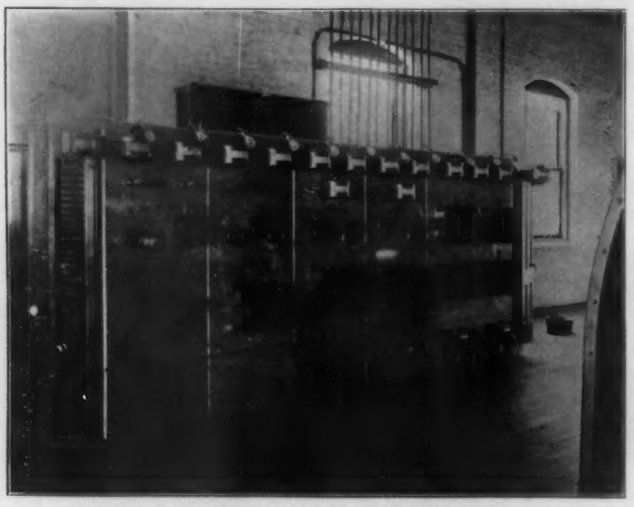
PLANING MILL AND POWER HOUSE, SHOWING POLE LINES AND SAWDUST BLOWER SYSTEM

giving ample room for all wiring connections, and the station circuits are on standard sub-floor construction.

The lighting load at present amounts to about 75 kilowatts, although upon completion of the match factory and the sash, door and blind factory, early during the coming spring, it will reach practically 100 kilowatts. It is divided as follows:

	Kilowatts
Planing mill and box factory	10
Dry kilns	5
Power house	2.5
Machine shop and foundry	7.5
General offices, etc.	7.5
Lumber sheds	10
Lumber yard	30
Sash, door and blind factory	10
Match factory	10
Car barn and pattern shop	10
Total	102.5

An idea of the character of the power service rendered by this plant is best conveyed by listing the motors used and the purposes for which they deliver power. All motors throughout the system are of the type "C" induction class produced by the Westinghouse Electric and Manufacturing Company.



THE MAIN SWITCHBOARD IN THE POWER HOUSE

Fifty horsepower in motor capacity is consumed in the handling of lumber through three separate applications, viz.: Twenty horsepower in unloading green lumber from flat cars in the yards, twenty horsepower in loading dried lumber onto flat cars as it is taken from the kiln, and ten horsepower in unloading the green lumber from flat cars prior to its distribution to the lumber yards.

The operation of the blower system for the conveyance of sawdust and shavings to the bins in the boiler house consume a motor capacity of 170 horsepower, comprising a 100 horsepower motor on the thirty-six-inch blower in the planing mill, a forty horsepower motor on a twenty-inch blower under the box mill, and a thirty horsepower motor on an eighteen-inch blower placed in the boiler room for firing the boilers with refuse taken direct from the bins.

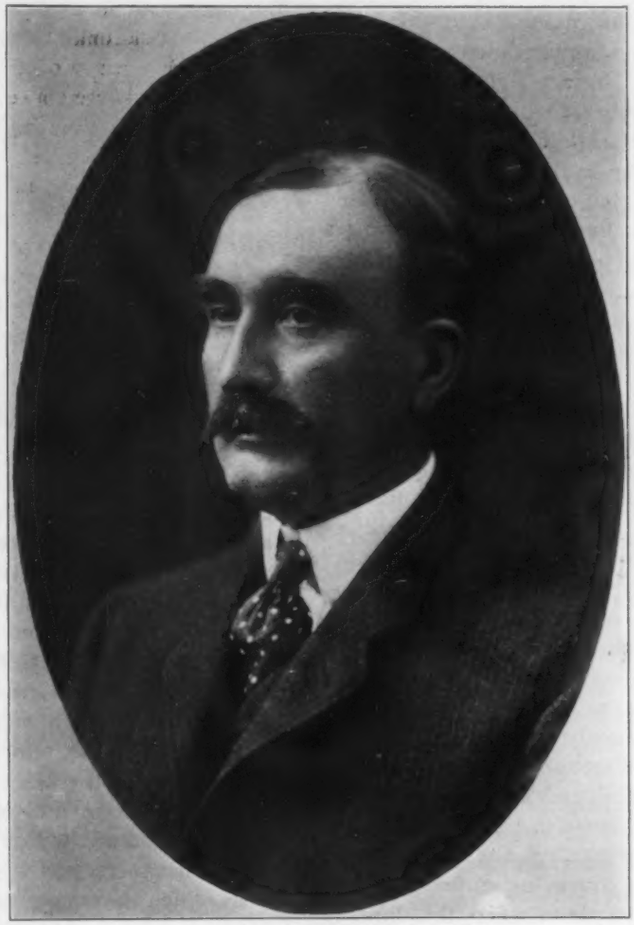
In the planing mill all motors, which are five in number, are located in the basement. A 200 horsepower motor is belted to the main countershaft, whence is

IN THE MACHINE SHOP OF THE DIAMOND MATCH COMPANY AT BARBER

driven all planers in the mill, the principal band re-saw is independently driven by a twenty horsepower motor and a motor of similar capacity also independently drives the "sander," as the sand papering machine is termed. A seventy-five horsepower motor drives the band re-saw in the box mill as well as four cut-offs and three circular saws, and a second motor, which is under the box mill, has a capacity of forty horsepower and drives a circular saw, a printing machine for labeling boxes, a band re-saw and minor machines. In the engineering department there are five motors with an aggregate capacity of 125 horsepower, namely, ten horsepower in the pattern shop, twenty horsepower in the blacksmith shop, and fifteen horsepower driving a blower in the foundry, while in the machine shop are two forty-horsepower motors, one of which drives the main countershaft whence all tools are run, and the other drives by direct-connection a thirty-seven and one-half horsepower, 220-volt, West-

inghouse direct current generator supplying current for the operation of the shop cranes. These are two in number; both are of Pawling & Harnishfarger build; that in the foundry having a capacity of ten tons and that in the machine shop having a capacity of fifteen tons.

Over 400 horsepower additional in motors is to be consumed in the two new factories which are now under erection. In the first of these, the sash, door and blind factory, 300 horsepower will be used; the second is to be the match factory, which will consume fifty horsepower in match making machinery and seventy-five horsepower in the operation of its ventilating system. The four new drying kilns now being built will call for another unloader, necessitating the installation of a twenty horsepower motor, so that the new work now under construction will consume approximately 450 horsepower. The present installation aggregates 700 horsepower, so that during the coming spring the total power load will reach about 1150 horsepower.



J. H. BAUGHMAN, CONSTRUCTING ENGINEER

The special applications of power are neither numerous nor very diversified; but they are, however, of no little interest, in fact interest in this direction centers in the blower system and the unloading machine. In all instances power is applied by belt-drive, and in the blower system draught pipes lead from each sawdust or shaving producing machine, and even from the "hog" in the planing mill, to the inlet of the blower, whence this fine refuse is driven to the bins or boilers, as may be desired in the power house, through the intermediary of the blower system of pipe conveyors with their "cyclones." Neither sawdust, shavings nor litter of any kind is seen in the planing mill, nor, in fact, is to be found in hardly any portion of the plant save in the bins provided for its storage.

The second interesting application of electric power is found in its use for driving unloading machines; that is, machines or conveyors used to facilitate the handling of lumber taken from or being loaded on flat cars or the special cars that run into the dry kilns. Unloading machines are of different styles and arrangement according to circumstances. A movable apron counter-balanced so as to enable its free movement to accommodate the height of the pile of lumber on the car and which is approximately twenty-five feet wide, carries four sprocket chains with steps which travel in a direction at right angles to the length of the car. The car, as well as the unloading machine, together with the transfer cars, tables and tracks leading to the dry kiln, are all roofed-in by a shed that has the stability of a warehouse.

The motor which drives the machine operates not only the sprocket chains which lift the lumber that is placed on it from the car to the sorter's table, but also drive the rollers which convey the lumber in an edgewise position from the sorter's tables to their respective kiln-car tables. As loaded on flat cars lumber is of various lengths, and the procedure followed in unloading is that the green lumber coming from the mountains is taken to the dry kilns at once in the most expeditious manner possible. The two men who are stationed on the flat car begin the operation of unloading by throwing the lumber onto the apron which raises it, as stated, at a speed of perhaps 120 feet a minute to the sorter's table. This man assorts the lumber by lengths into the proper one of nine channels, standing the plank on edge on live rollers which carry it forward to the proper table whereon it is automatically dumped in front of the kiln car carrying its particular lengths.

The kiln cars consist of three malleable iron frames, each of which supports two track wheels and each of which has a socket for a 4" x 4" x 10' timber in its ends. The cars therefore occupy three rails, and counter weights attached thereto keep the cars pulling against guide posts of 8" x 8" timbers that support the gallery of the distributing tables. The planks are shoved down edgewise between the front car posts and the gallery posts, and when the tier is full, separating strips having a cross-section of 1" x 3" are placed in upright positions and held there by gravity braces. Against them the next tier of planks is dropped down edgewise, and as the first plank of the second tier is placed the car moves outward, and so on until it is filled, when its posts are bolted together and it is run into the dry kiln directly opposite.

The manner in which the dry lumber is taken from the kiln car and delivered to a distributing table by con-

veyors is another application. This equipment is driven by a ten horsepower motor, as stated, and its simplicity is greater than that of the machine for unloading flat cars, because of the elimination of the sorter's table.

The lumber handled by the machines thus far described is dried and almost immediately taken to the planing or other mills nearby, where it is worked up. If, however, the lumber is not be worked up at once, it is taken on the flat cars as brought from Sterling City and "spotted" on the opposite or eastern side of the lumber yard, where it is unloaded by another twenty horsepower machine which is of a different type than that already described, in that it possesses an apron of greater flexibility or of a wider range of action than that described, and in that further it carries the unloaded lumber down a long distributing table from which it is taken by hand and carted away in accordance with lengths marked on each piece by the sorter. It therefore differs from the other unloading machine especially in that it does away with the sorter's tables and rolls; but on the other hand this particular machine requires the services of a marker who marks the quality of each piece of timber that passes with its grade.

The remaining applications of electric power present familiar uses and need not be enlarged upon, as they embody no distinctive innovations. A genuine surprise, however, awaits the visitor to the engineering department of the plant, who will hardly be prepared to find a full-fledged iron works, complete in every detail, from foundry to paint shop, where even standard railway coaches are given finishing touches. Here locomotives are repaired, logging engines are built complete from the first patterns for the castings to the journal bearings, sawmill machinery is made, as are also railroad specialties, such as frogs and switches, and, in brief, there is nothing that these shops cannot produce or repair in the way of mechanical appliances used in any of their industries. And all is electrically driven.

The master mind in the direction of the building of the great enterprises executed under the name of The Diamond Match Company, including the logging and sawmill undertakings at Stirling City, the Butte County Railroad, built primarily for conveying unfinished lumber from the mountains to the plains where the shipping point is located, and the great finishing mills at Barber, is that of F. M. Clough, Pacific Coast manager for the company. Mr. Clough has been prominently identified with The Diamond Match Company for the past fifteen years, the majority of which have been devoted to the management of the so-called outside interests of the company, such as the acquirement of new timber lands and milling properties. Every executive detail in the entire undertaking has been cared for by Mr. Clough personally through the authority conferred on him by the president of the company, O. F. Barber, and its general manager, W. M. Graves, and in the work which Mr. Clough has had in hand he has been most worthily assisted by J. A. Baughman, constructing engineer for The Diamond Match Company, under whose immediate direction all engineering details were planned and executed. It is in slight appreciation of the services they have rendered to the engineering industry of the Pacific Coast, if not of the country, by the building of such works, that their likenesses are presented in connection with this all-too-brief description of a single instance of the fruit of their labors.

THE DESIGN AND CONSTRUCTION OF TALL CHIMNEYS OF REINFORCED CONCRETE.

*BY GEORGE COTNER MASON.**

IN an article entitled "Concrete and Concrete-Steel in the United States,"† written by Edwin Thatcher for the International Engineering Congress, held in St. Louis just one year ago, there appears this statement in reference to a concrete-steel chimney built for the Pacific Electric Railway Company, at Los Angeles, Cal. "It has a height of 158.5 feet above the grade and 174 feet above the foundation, and has an inside diameter of eleven feet. This is believed to be the highest concrete-steel chimney in the world." Only one year ago, and now that chimney of its kind, "the highest in the world," has become comparatively small.

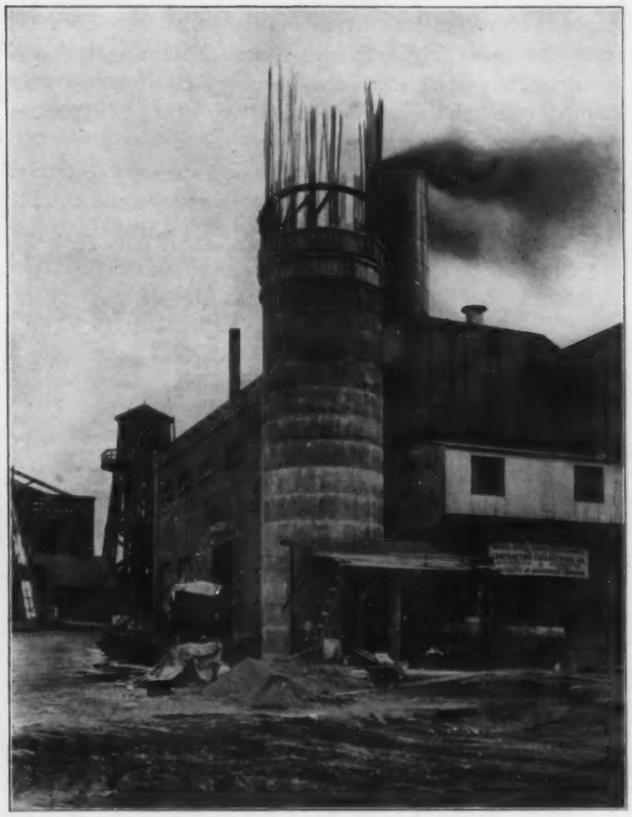
During the past year the author has had the opportunity to erect two chimneys which dwarf into comparative insignificance the big chimney of one year ago.

One chimney erected for the Portland General Electric Company has an inside diameter of twelve feet and rises 230 feet above grade. Another built for the Tacoma Smelting Company, in Tacoma, Wash., has an inside diameter of eighteen feet and stands 300 feet above grade. The latter is today the largest chimney built of reinforced concrete, but even now this is beginning to shrivel up in comparison with one in course of erection at Butte, Mont., which is to be 450 feet high.

In the design of a power plant chimney there are several matters which require consideration. Perhaps the first is the size, which includes both the interior cross-section and the height. In order to determine the proper cross-section and height of chimney it is necessary to understand the theory of chimney draught. The old idea that there was some inherent power in a chimney by which the smoke and gases were drawn up has long since given way to the now well-established fact that chimney draught depends wholly upon the difference in weight or density of the atmosphere at different altitudes, hence the greater the height of chimney the greater this difference in density and consequent increased draught. This is true up to a certain point, other things remaining the same. There must be sufficient area for the volume of smoke, or there will be a back pressure which materially retards the draught. All this seems very elementary, but it is nevertheless essential to a correct design both as to size and as to materials used in construction.

* Contracting and Engineering Company, Portland and Tacoma.

† Transactions of the American Society of Civil Engineers, Volume LIV, Part E, page 431.



CONCRETE CHIMNEY IN COURSE OF CONSTRUCTION

Numerous formulæ have been developed by which the correct size may be determined to meet given conditions. Very few of these take into consideration the character of the inside chimney surface, and this has an important bearing upon the question. If this surface is rough, it must necessarily retard the draught and require a greater height to meet the needs of the plant. If it is a good conductor of heat, the air in the chimney becomes rapidly cooled and the draught to that extent is retarded.

One of the simplest of the formulæ, which serves the purpose as well as any other, and from which the necessary height and cross-section may be obtained, is that given by Kidder, viz:*

$$E = \frac{0.33}{\sqrt{h}} = A - 0.06\sqrt{A} \quad \ldots\ldots\ldots \quad (1)$$

$$H = 3.33\, E \sqrt{h} \quad \ldots\ldots\ldots \quad (2)$$

$$S = 12\sqrt{E} + 4 \quad \ldots\ldots\ldots \quad (3)$$

$$D = 13.54\sqrt{E} + 4 \quad \ldots\ldots\ldots \quad (4)$$

$$h = \left(\frac{0.3\, H}{E}\right)^2 \quad \ldots\ldots\ldots \quad (5)$$

In which H = horsepower.
h = height of chimney in feet.
E = effective area in square feet.
A = actual area in square feet.
S = side of square chimney.
D = diameter of round chimney in inches.

When this size has been determined, the character of the chimney is next to be considered. In this regard there are three kinds which naturally suggest themselves, brick, steel and concrete.

Where brick is cheap and ground space not too valuable this form of stack offers several advantages. Any shape or form of chimney is easily constructed and the brick offers the necessary resistance to moderate heat. It offers considerable friction by reason of the many joints between the brick, and where intense heat is to be carried the brick chimney must be lined with fire-brick and fire-clay. The steel chimney is the cheapest to construct under reasonable conditions, but is the most expensive to maintain and has the shortest life of the three. The steel chimney, if made self-supporting, again becomes expensive, and the guys for one of shell construction are certainly not ornamental and may be a source of danger. If kept clean, the steel chimney offers little friction to the air, but it is too good a conductor of heat to make an ideal construction.

The third form seems to meet the requirements to a far greater extent. Monolithic concrete is smooth on the surface, a non-conductor of heat, requires no lining to resist any temperature, at least up to 1500° F., requires no expense for maintenance, and because of its inherent properties becomes stronger and better with age. As to first cost, the three usually rank—steel, concrete and brick. As to final cost, they almost invariably shift this order to concrete, brick and steel. The difference even in first cost between concrete and steel is rarely so great as to warrant the use of steel for this reason for any but temporary purposes. The ground space, which is often very important, is economized to the greatest extent by the use of reinforced concrete—the saving over brick being about one-third. Until the development of a suitable system of reinforcing concrete it was impossible to use it in tall chimney construction, the tensile strength of concrete being insufficient to economically resist the wind stresses. At this time it is not necessary to more than enumerate the principles upon which reinforced concrete depend. The steel is imbedded in the concrete to take care of the tensile stresses, the concrete itself resisting those due to compression. Steel properly imbedded in concrete does not rust or otherwise deteriorate. Steel and concrete in proper combination act not as two materials, but, by reason of their adhesion, practically become one and act together. The coefficient of expansion, which of course is a matter of considerable moment in a chimney subjected to great heat, is for all practical purposes the same in both steel and concrete. Much has been written about the adhesion of concrete to steel, very much of which is for business purposes rather than engineering. This much seems to have been proven—that the adhesion varies directly with the exposed surface area of the steel, and as the strength in tension depends upon the sectional area, the end desired is to get the greatest surface area exposed for adhesion with the requisite cross-section for tension. Inasmuch as T-steel gives a superficial area of almost twice that of round or square bars. The T-shape was used in both these chimneys.

*"Architects and Builders' Pocket-book," page 1222.

There are many forms of patented bars which, by reason of their form, offer mechanical as well as chemical resistance to slipping. As a general proposition these forms are all good, the objection to their use being two-fold in this country—additional cost and difficulty of obtaining them on short notice. Whether this additional cost is warranted depends on circumstances, which vary in almost every instance.

When it comes to the mechanical calculations for the amount of steel and the thickness of concrete required it is necessary to assume unit conditions.

In 1902 the design of chimney stacks was regulated in Germany by an act governing the (unit allowable) stresses and loads as follows:*

Wind pressure—W = 25.6 pounds per square foot.

Rectangular chimneys designed for full pressure.

Round stacks 0.67 of W.

In calculations for compressive stresses on the lee side W shall be taken as 30.8 pounds per square foot.

The permissible stresses on the brick-work of the structure are taken as: (1) For common brick masonry laid in 1:3 lime mortar 100 pounds per square inch; (2) for masonry of hard burned brick laid in lime-cement in cement-mortar 171 to 214 pounds per square inch.

In any particular case a higher unit compressive stress, up to a maximum of 356 pounds per square inch, may be used, provided it be demonstrated to the authorities, by actual test, that the contemplated unit stress will give a factor of safety of at least ten. If the foundation is made of concrete, the maximum stresses in the latter are limited to 85 to 114 pounds per square inch when the concrete is simply deposited, or 142 to 214 pounds per square inch when concrete is rammed. The foundation pressure on good soil shall not exceed 3.1 and 4.1 tons per square foot.

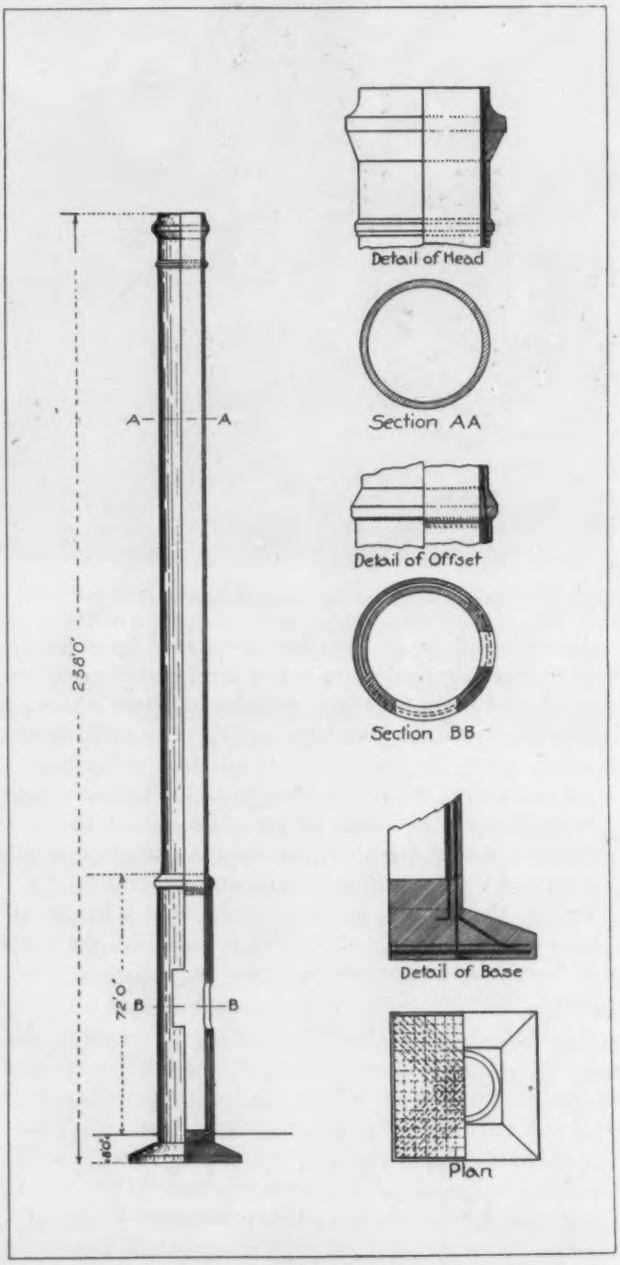
The author has quoted the German practice in order to make a comparison with methods employed here as well as stresses allowed. In the design of both the large concrete chimneys already mentioned the following were the unit stresses and loads.

A unit wind load of fifty pounds per square foot was taken as against 25.6, but only one-half was assumed as effective on these chimneys because of the circular plan. The resulting comparison of actual wind load was consequently 25 pounds per square foot as against 16.7.

The concrete was assumed at 150 pounds per cubic foot, and upon this assumption the weight was determined and size of foundation required so as to have the load on the soil less than one ton per square foot. In each case a test load was placed on the soil of between three and four tons and permitted to remain forty-eight hours. As no settlement took place the foundation was considered satisfactory.

The tensile strength in steel was 16,000 pounds per square inch, and a sufficient number of bars introduced to care for the total tension caused by wind. The stack was divided into sections and designed accordingly. The first was taken at the base, another forty-two feet above grade, a third at the offset, a fourth fifty feet from the top. At this height it was found that no steel was required, the weight of the chimney itself being sufficient to resist the wind, but thirty-two bars were inserted nevertheless.

The arrangement of the foundation steel was intended to thoroughly spread the load and at the same time to



DETAILS OF THE CONCRETE CHIMNEY OF THE PORTLAND GENERAL ELECTRIC CO.

get a perfect bond between the chimney and foundation, making both a monolith.

To accomplish this end, the steel was laid in a bed of concrete which covered the soil in the form of a rectangular net of two-foot mesh. After more concrete was put on this, a diagonal series of nine bars each ran the entire distance between opposite corners.

* *Engineering News*, July 10, 1902.

The vertical rods from the stack were brought well down into the concrete below the steel reinforcement of the foundation and bent under them.

To effectually tie the vertical rods together and better distribute the pressure, a series of horizontal rings were used, made of 1" x 1" x 1/8 Ts on 18" centers in inner shell and on three-foot centers in outer and single shell.

The double shell is used at the lower quarter of the chimney, so that the intense heat will not come in direct contact with the supporting portion—*i. e.*, the portion resisting the wind pressures. In this way the inner shell, which does not touch the outer, is left free to expand independent of the real structure.

The forms* are sectional in construction and made of the barrel-stave type, with clamps at top and bottom of each section to hold them firmly in place. One form three feet in height is set in place, and after the concrete is thoroughly rammed and brought to the top, the upper form is placed on the lower and the concreting continued. In raising the forms the lower ones are hung from the upper by means of ropes over hooks; they are then unclamped and raised section by section. Care must be taken in the construction of forms to allow for the swelling due to the water in the concrete and still give a perfectly smooth joint against which the concrete is rammed. The rods are held in place by means of a wooden ring bored for the proper spacing of the rods. This ring is raised as the work progresses and supported on simple scaffolding carried on the inside.

The only scaffolding required is that necessary to carry up a working platform on the inside of the chimney.

The mixture of cement and sand was 1:2 at the base and 1:3 at the top. The concrete was mixed in a continuous mixer and hoisted in buckets on the inside of the chimney. These buckets are carried up on a frame of radiating arms worked from a drum attached to the mixer. A ladder is built up on the inside as the work progresses by which the men go up and down to the working platform. The usual rate of progress is three feet a day on the double shell and six feet after the single shell is reached. In the construction of the chimney in Portland the contract called for completion on May 20th, so that it would be available at the opening of the Exposition. The work was completed and the chimney in use six days ahead of contract time. Not one day was lost from the beginning of the work, and the entire structure, including foundation, was finished in fifty-six days.

THE SINGLE PHASE RAILWAY.†

BY M. P. RANDOLPH.

Before the advent of interurban and long-distance electric railroading, the direct current system filled the requirements, as the lines at that time were confined almost entirely to city streets and similar short distances. With the extension of existing city lines into suburbs and to nearby towns, the need of higher transmission voltage became apparent. The difficulties of motor design limited the voltage to about 600 as the maximum, and the comparatively slight increase from 500, the electromotive-force formerly employed, to 550 and later to 600 volts, only partially filled the requirements. The excessive cost of conductors for transmitting any considerable amount of current under such conditions placed such limitations upon the mileage that could be operated with commercial success. With the development of the rotary converter, it became possible to transmit a greater part of the power consumed by high tension alternating current, the local distribution still remaining 600 volts direct current.

The use of sub-stations represents an investment in costly apparatus that requires constant attendance; but the system is entirely reliable, satisfactory and commercially successful where traffic is sufficiently large to yield a dividend on the investment required.

In spite of the commercial success of direct current electric railroading, it became apparent that an ideal system would be one in which alternating current could be used throughout. With such a system the rotary converter would be eliminated; a higher voltage could be utilized on the trolley which could be reduced on the car by means of a transformer and a part, if not all, of the expensive feeders could be done away with. With such a system the transmission voltage could be reduced to the desired trolley voltage by means of transformer stations which require no more attention than a section of high tension transmission line. The practical realization of such a system has long been delayed, however, by the lack of suitable alternating current motors, and it is only within about two years that such machines have been demonstrated commercially successful. Prior to this time the only alternating current motors on the market were of the induction type.

The polyphase induction motor, although well adapted for ordinary constant speed work, is entirely unsuited for traction purposes. Aside from the necessity of using two working conductors (in addition to the ground) and the complication and inefficiency of the speed control, the characteristics of such motors are so poorly suited for railway work that any advantage gained in transmission by the use of alternating current is more than offset by the inadequacy of the motors.

The polyphase induction motor has to a large extent the same speed-torque characteristics as the direct current shunt motor. It is well understood by railway engineers that direct current motors of this type are not suitable for starting and accelerating a car or train, since they can produce the large torques which are necessary for such work only by the use of correspondingly large current and power. Even when the car is up to speed, the shunt motor is not suitable for driving it since the motor runs at a practically constant speed regardless of load, and consequently the car would run on the level at only the same speed as it would run in ascending the

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*Forms patented by the Weber Steel-Concrete Chimney Company.

†A paper read before the Electrical Transmission section of the Pacific Coast Engineering Congress, held at the "American Inn" under the auspices of the Lewis and Clark Centenni Expoiition Portland, Or., June 29-30, 1905.

heaviest grade. It would thus require only a very small amount of power on the level and a very large amount on grades, causing great fluctuations in the power demand on the system; moreover, an excessively large and costly motor would be required for a given weight of car on account of the large output necessary on grades.

With the series motor, however, the torque increases more rapidly than the current so that with twice full load current three or more times full load torque will be obtained. The series motor also tends to maintain a constant output, running at a high speed on grades where the torque required is large, so that the demand for power is much more constant, the maximum output is less, and a smaller motor will suffice for a given car.

The similarity of the polyphase induction motor to the direct current shunt motor as regards characteristics has, in general, been appreciated in this country, and on this account alternating current railway systems using polyphase induction motors, have never been seriously proposed, although they have been used to some extent in Europe. American experience with direct current railway systems has shown conclusively that the series motor is the only satisfactory type for such service, and it is thus essential that an alternating current railway motor should have series characteristics in order to be successful.

As early as 1892 the Westinghouse Electric and Manufacturing Company considered the advisability of producing a series alternating current motor for railway work. The general state of the electrical industry at that time when high frequency generators, principally intended for incandescent lighting, were the usual rule, proved a drawback to rapid development. In 1902, motors which were entirely satisfactory for operation with current of 16 2/3 cycles, or 2000 alternations were produced. A contract was taken to equip a large road with this apparatus, but owing to financial difficulties of the railway company the line was never put into operation. One of the equipments, which consisted of four 100-horsepower motors, together with the necessary auxiliary devices, was completed, however, and was operated almost daily for nearly two years on the Interworks Railway at East Pittsburg, where it was seen by hundreds of visitors until a short time ago, when it gave place to a more modern twenty-five-cycle equipment.

The experience gained by the Westinghouse Company with this equipment, together with the previous experience covering over ten years, placed the single phase railway system where it was no longer an experiment, so that in 1904 a number of contracts were taken for equipping railways with such apparatus.

There is a similarity in construction between the single phase railway motor and the box type direct current railway motor. The magnetic circuit of the field, however, is entirely laminated and consists of a number of annular punchings with poles projecting radially inward. These are assembled together and held in a cast steel frame.

The poles are shorter than is ordinarily the case in direct current motors and the field coils consist of only a few turns of very heavy strap or wire. Lying in slots in the poles, is an auxiliary or compensating winding which, although located on the field, is really in effect a part of the armature winding. This winding is also of heavy section and has but few turns. The motor is of straight series type which means that all of the windings are connected in series.

The armature is similar in appearance and construction to that of a direct current motor. As the motors are wound for only 250 volts, it has not been found feasible to use only two brush arms, as in the ordinary sizes of direct current motors, but in sizes up to 100-horsepower inclusive, four arms are ordinarily used. These are so arranged, however, that all may be gotten at by removing the lid over the commutator.

The performance of the alternating current series motor is very similar to that of its direct current progenitor. It has a somewhat steeper speed curve, however, and the additional hysteresis, eddy current and similar losses due to alternating current, together with the greater friction due to the larger number of brushes, naturally tend to make the efficiency slightly lower than that of the direct current motor. But this is more than offset by the increased efficiency of the system as a whole. Power factors in the neighborhood of eighty-five per cent. at full load are readily obtained and at half load and less, where a motor usually runs for a majority of the time in interurban service, the power factors of commercial motors range from ninety per cent. upward, so that an average power factor of from eighty to eighty-five per cent. for the system should be readily obtained.

As with the direct current motor, the speed of the alternating current railway motor depends on the voltage applied. Speed control may be obtained by the use of a resistance in series with the motor, but, in general, the ease of obtaining reduced voltage with alternating current renders rheostats and the loss of power due to them, unnecessary. The voltage required to force a given current through the armature circuit depends on the speed of rotation, but that required for the field depends only on the current. The voltage across the field of a 250-volt motor of this type at full load may be in the neighborhood of 100 volts and this same voltage would be required to send full load current through the field even with the motor at rest. As a result of this fact a much higher relative voltage is required to force any given percentage at full load current through the motor for starting than is the case with direct current, about half or more of the full voltage in some cases being necessary to give full load current with the motor at rest. One result of this is that the motor is much less likely to be damaged by too rapid feeding up of the controller, than is a direct current motor.

The commercial production of the alternating current series motor made this system possible; therefore, its particular features have been dwelt upon at some length. It is not in any advantage possessed by the motor, however, that the merit of the system lies; but it is due to the use of alternating current.

Many of the details of the car equipment are also worthy of notice as contributing their share to the success of the system.

In order to reduce the trolley voltage to a suitable value for use at the motors, a special form of air blast transformer has been developed. These transformers are arranged for mounting beneath the car and for being cooled by a small blower mounted inside the transformer case.

A variable voltage for controlling the speed of the motors being necessary, the method of obtaining it which naturally suggests itself is to bring out taps at different points from the transformer and to connect the motors successively to these. For small equipments this is done by means of a hand-operated controller similar in general appearance to any ordinary railway controller. For larger equipments the same connections are made by means of pneumatically operated switches located beneath the car. Since with such a control system reduced speed is obtained by transformation of voltage and not by the introduction of any additional source of loss (such as a rheostat), it is evident that when a car is running at any reduced speed, the energy required is also reduced.

The standard trolley voltage for alternating current railways is 3300 volts, and higher voltages may be used in special cases. For operating with such trolley voltages, especially with multiple unit trains, it is desirable that some form of trolley be used which can be raised and lowered from inside the car and without the direct handling ordinarily required with the ordinary form. To meet this condition, a form of bow trolley has been devised. This trolley is made without the swivel base to take care of the side variations. The trolley consists of two parts, a main framework and a light contact bow hinged to it. This trolley is entirely under the control of the motorman. By admitting compressed air to a pneumatic cylinder he can raise the trolley until the contact bow strikes the wire, and by releasing the air he can allow the trolley to fall flat against the roof of the car. When the air is on, the main frame of the trolley assumes a certain angle with the top of the car, depending on the height of the wire; the contact bow then assumes a position about thirty degrees behind a vertical line from the top of the main frame. With this trolley the car can run either forward or backward with no change, the main frame remaining exactly the same and the contact bow adjusting itself in the proper direction, without attention. The contact bow is made very light so that it can readily follow any slight variations or irregularities in the wire.

In general, the weight of the single phase alternating current motors is not materially greater than that of direct current motors of the same capacity. A complete equipment including all apparatus will weigh approximately fifteen or twenty per cent. more than a direct current equipment of the same capacity. Since the weight of an equipment usually forms only about one-fourth of the total weight of the car, equipment and load; however, a car equipped with alternating current apparatus should in general exceed the weight of one equipped with direct current apparatus by less than five per cent.

When new suburban or interurban lines are constructed it is sometimes necessary to use existing lines through towns or cities of any importance, as desirable routes leading to the business centers are often monopolized by local companies. In some cases, existing direct current loads would like to obtain the advantages of single phase operation on branches and extensions, but must have cars on the new line which can operate on the old line. These conditions may be taken care of although at the expense of somewhat greater cost and complication, by the series alternating current motor, which is merely a direct current motor with some special features, and which will operate well with direct current if supplied with the proper voltage. This fact, together with the above conditions, has led to a demand in some instances for equipments which will enable the advantages of alternating current to be obtained when running in open country, but which may be run in cities and towns with 500-volt direct current. Such equipments are possible, but there are several reasons why they are not entirely desirable. Although the motors will operate just as well with direct current at 250 volts as with alternating, the controlling devices will not. The auxiliary devices which give the best results with alternating current are not at all suitable with direct current. It is usually impracticable to provide duplicate sets of auxiliary apparatus, owing to lack of space under the car in which to mount it; this means that if the car must operate on both alternating and direct current, a compromise must be made and the results of both alternating and direct current sacrificed somewhat in order to be able to operate with both.

There are, moreover, certain essential pieces of apparatus, such as the transformers, etc., which must be entirely cut out of circuit when direct current is used, as well as various connections which must be changed when alternating current is used; and it is the apparatus for doing this which adds to the cost and complication of the equipment.

The alternating current system is finding its first use on interurban roads where, at most, only a small part of the total mileage is in cities or towns. In such roads there are but few cases where direct current operation is absolutely necessary. In many instances, for example, it may be avoided by the use of an additional trolley wire carrying alternating current. In cases where operation on both alternating and direct current is necessary, it can be secured; but this must be done at the expense of greater cost and greater complication of apparatus as well as somewhat less flexible operation.

Owing to the high voltage used with the single phase railway system, a special form of line construction has been developed which has features that render it particularly suitable for the operation of high speed cars or multiple unit trains. The essential features consist of a grooved trolley wire which is held in position by catenary or messenger cable suspension suitably insulated

and held firmly in place. This form of construction may be supported either by span wires or brackets.

The "messenger," or supporting cable, is made of stranded galvanized steel. It is suspended in spans of 60 to 120 feet, according to circumstances, and is placed two and one-half feet above the height of the trolley, at the end of each span. The trolley wire is suspended from the messenger cable by means of rigid galvanized iron hangers every ten feet, of such lengths that the trolley wire itself is parallel to the track. From three to six different lengths of hangers are required, according to the length of the spans. The messenger cable being connected to the trolley serves also as an auxiliary conductor in addition to supporting it. Corrugated porcelain insulators are used.

In suspending the messenger cable, a band or strap is placed about the insulator, having upon its lower side an eye through which is passed a double hook fastened to the messenger cable. The line insulators may be fastened directly over the center of the track when wheeled trolleys are used, or may be placed alternately to the right and left of the center of the track in order to make a more even wear on bow trolleys. To protect the line insulator from possible damage should a trolley leave the wire, a guard is formed by attaching to the insulator sleeve two heavy wire loops or stirrups, projecting diagonally toward the ground in opposite directions, and fending off anything which is liable to damage the insulator from below. Should the messenger cable become detached from the insulator, it will rest in these stirrups which pass beneath it and will thus be prevented from falling.

At intervals of 1000 feet, on a straight track, a supplemental arm is attached to the bracket by means of an insulator upon the diagonal arm of the bracket, the outer end of the arm is secured to the trolley wire in the same manner as the hanger clamps. This serves to keep the catenary structure in an upright position and to correct any tendency to a sidewise motion.

Suitable section insulators, curve pull-offs, and all other necessary line devices have been designed and constructed along similar lines.

Since the standard trolley voltage at present is 3300, while transmission voltages of 15,000 or 20,000, or more would ordinarily be used, transformer stations are provided at suitable points along the line. Since these transforming points need contain only the necessary oil insulated self-cooling transformers with their switching and protective apparatus, the buildings may be of the simplest character and of very small size. For housing a 300 K. W. transformer of this type with the auxiliary devices for a 20,000- to 3300-volt transformation, a building twelve by fifteen feet in section and twenty feet high will, in general, afford ample room. These stations may be regarded merely as a part of the high tension transmission line, and as a rule should require no more care and attention than it does. The distance which may be allowed between sub-stations will depend, of course, on the voltage used and on the maximum demand for power between stations.

The voltage drop in the track rails is considerably higher with alternating current than with direct current of the same amount, and there is, in addition to the actual ohmic drop in trolley wire and rails, a drop due to their inductance. For ordinary purposes, however, it is sufficiently accurate to group these together as "apparent resistance."

Tests made on a three-mile stretch of No. 000 trolley wire 7/16-inch messenger cable and a single track of eighty-pound rails indicate that the apparent resistance of such a circuit with twenty-five-cycle alternating current is approximately 1.8 times the ohmic resistance, and that the drop in voltage for this circuit is approximately sixty volts per hundred amperes per mile. Combining this increased resistance of the circuit for alternating current with the power factor (which we may take as ninety per cent.), it is evident that if a given amount of power is transmitted for a given distance over such a circuit with both alternating current and direct current at the same voltage, the percentage drop in voltage with the alternating current will be twice that with direct current. The percentage drop is proportional to the square of the voltage, and in order to keep the same percentage drop with both currents, the alternating voltage must be made approximately 1.4 times the direct current voltage. This means that a trolley voltage of 840 with alternating current is just equal, for transmission purposes, to direct current at 600 volts.

With alternating current, however, quite high trolley voltages may be readily used, while with direct current about 600 volts at the motors is the maximum limit. With 3000 volts on the trolley, for instance, or five times the ordinary direct current voltage which offers no particular difficulties, the percentage drop on such a circuit is only eight per cent. of that with direct current.

The first application of the single phase railway system will undoubtedly be in the field of interurban work, for it is not expected that the alternating current system will supersede the direct current in the near future. Consequently the various details that have been described with particular reference to such service.

Taking up the subject of economy, the relative amount saved in any given case will depend largely upon local conditions. The principal saving will undoubtedly be in the first cost of the transmission circuits, which is ordinarily the case where alternating current transmission is adopted. There will also be a saving of the cost of rotary converters and their accessories; in sub-station buildings, as the size required for a transformer station is much smaller than for rotary converters and, further, since transformer stations do not require constant attendance, a saving in operating expenses will be made.

Against these savings must be placed the somewhat greater cost of the alternating current equipment as compared with the direct current.

There are many districts in various parts of the country too sparsely settled at present to support a direct current railway, which are, nevertheless, badly in need of better transportation facilities and which may prove attractive investments for a cheaper railway system, and it is from such sources that the immediate demand for the system is coming.

Another field which presents itself for the alternating current railway system, is the equipment of present steam lines, or what has often been spoken of as the heavy railroad problem. Although the only steam roads which have been, or are being, equipped electrically, use direct current, the direct current motor has never been considered as entirely suitable for this work, as usually but two speeds, and at most but three speeds, can be obtained where four motors are used—the third speed increasing the complication considerably. With the alternating current motor of the commutator type, any speed can be obtained for locomotive work, because any voltage can be supplied to the terminals of the motor. As soon as alternating current is used (for motors) we at once have a ready means of voltage transformation.

This single phase system is the one means presented at the present time as the solution of the heavy railroad problem. It has all the advantage of the direct current motor in the variable speed characteristic, and has also the advantages possessed by alternating current in the ability to use any line voltage desired, and to vary the voltage applied to the motor and thus vary the speed over any range desired.

Even for city service, the alternating current system has some features which may some day bring it to the front in what is now regarded as an impregnable direct current stronghold. Among these advantages may be mentioned the better facilities for operating in crowded streets, due to the more flexible speed control and the absence of electrolysis with alternating current.

It is evident that the single phase railway system has come to stay, and it is not unreasonable to expect that the use of alternating current for railway service will have almost, if not quite, as far-reaching an effect as did its use for incandescent lighting and general power transmission.

THE VALUE OF SAWMILL REEUSE AS A FUEL.*

BY O. B. COLDWELL.

The manufacture of lumber is the chief industry of Portland. Along the river front of the city, extending from St. Johns to Sellwood, are located thirteen sawmills, the combined output of which approximates 2,700,000 feet every twenty-four hours. Oregon is noted for its timber, and its citizens are justly proud of the position occupied by the State as a producer of fine lumber.

There is a by-product of this industry which is of considerable importance. This by-product is the one I have chosen to discuss in this paper.

With every 1000 feet of the finished product there is made from thirty-five to fifty cubic feet of sawdust, depending upon the type of saw used, the circular saw producing about one-third more dust than the band saw. The first cuts taken on a log are not suitable for lumber, and appear as part of the by-product in the form of slabs. It is a comparatively easy matter to find a market for the finished high-grade product, but the disposition of the low-grade lumber and refuse is a matter of study on the part of all mill men.

For each 1000 feet of the finished product there is produced about one-fourth of a cord of slabs. On the basis of 2,700,000 feet there is therefore produced each day, in Portland, about 113,700 cubic feet of sawdust, or 568 wagon loads of 200 cubic feet each, and 677 cords of slabs. About seven per cent. of the hands employed in the mills are occupied in the disposal of this by-product, and there is one firm alone employing 250 men which makes a specialty of retailing the slabs and sawdust. A number of the mills operate lathe mills, selecting the best of the slabs for this purpose, and thereby working up a portion of the by-product. By far the greater part of the slabs, however, is hauled away from the mills to be used as fuel under boilers and as wood in homes. Large quantities of slabs are burned under boilers in the steamboats of the Willamette and Columbia Rivers.

Mill men have found that it is essential to use some form of conveyor to carry away the dust as it leaves the saws, and one is immediately struck with the importance of these conveyors in the general scheme of the mill. I will not attempt to go into the details of the conveyor systems used, but will mention a few types in common use.

A V-shaped trough, through which travels a steel cable provided with cast iron washers about six inches in diameter, makes an efficient conveyor of sawdust, when there are not too many sticks mixed in with it. This type is largely used in some of the mills. Another form consists of a steel link chain supplied every three or four feet with hard wood flights, the whole traveling in an iron-lined trough over sprocket wheels. This makes a very satisfactory conveyor and will stand a great amount of rough usage, to which it is many times subjected on account of the sticks being mixed in with the sawdust which it must handle. Occasionally bucket carriers are used, but these are not so much in favor as the first two types mentioned. In planing mills a method largely employed is sucking the sawdust and shavings away from the planers, and blowing it by means of rotary fans to the point desired. This method is only possible when the material handled consists of fine dust and shavings that are free from sticks.

A machine which forms a very important adjunct to the apparatus for disposing of the by-products of a mill is the "hog." This machine consists of a series of knives, mounted on a suitable revolving part, running at a high rate of speed, which slice up a slab of wood at a remarkable rate. It is largely due to the efficiency of this machine that the mill man is able to dispose economically of its by-product. The machine is well named, for it can

dispose of any by-product of the saw mill, no matter in what shape it may be, digesting it in very short order. Slabs, planer trimmings, bark and wood waste material of all kinds is carried by the conveyor systems from all points of the mill to the hog. The conveyors are situated under the roof trusses and floors, pass under the saws, and up and down in a multitude of ways. When it is desired to convey at an angle, one chain dumps its load on to another, running on another set of sprockets. The output of this hog, or cut fuel, as it is called, is allowed to mix in with the sawdust, and it is this mixture that forms a large proportion of the by-product.

The mills all operate by steam power, the fuel consisting, in every case, of the mixture above mentioned. The conveyor system extends into the boiler room of the mill plant and usually over the top of the boilers, the fuel feeding into the ovens through narrow slits between the drums of the boilers. In some cases a Dutch oven is used, and the fuel feeds directly into the top of this. This oven is one which extends forward from the boiler setting. In the case of the planing mills, the blower system is sometimes extended into the firebox of the boiler, the sawdust and shavings blowing directly into the fire. There is, of course, a large surplus left over, and this the mill owner must dispose of as best he can. Some years ago,, when the number of manufacturing industries was not so large as at present, most of the mixture was dumped. There are in the neighborhood of the older mills acres of fills made of sawdust, planer trimmings, etc.

Slab wood is largely used as a fuel in the homes of Portland, being ordinarily cut into stovewood lengths by gang saws, specially arranged for the purpose. Many factories and plants use four-foot slabs instead of cord wood, for coal is sparingly used in Portland. Saw mill refuse fuel is used extensively under boilers of manufacturing concerns in the city and is delivered in box wagons carrying from 135 to 200 cubic feet of fuel.

I have aimed, in the foregoing, to give an idea of the lumber industry in Portland and of its by-product. I now desire to call attention to the use of the by-product as a steam producer, especially as related to the manufacture of electrical energy.

Mr. Sykes, in his paper, has told you of the steam stations of the plants of the Portland General Electric Company, known as Stations C and E, located at Twenty-first and Nicolai streets. These combined plants are the largest users of the mixture of sawdust and cut fuel in the city, taking as they do, from 100 to 150 loads every twenty-four hours, from two of the largest mills in Portland. The Portland Consolidated Railway Company has a plant, located at the foot of East Grant street, which is the second largest user of cut fuel. I propose to describe somewhat in detail the method of handling the fuel at the steam stations of the Portland General Electric Company.

In choosing a site for the location of a power plant which is to use cut fuel, it is desirable to get as close to the source of fuel supply as possible. The plants above mentioned are, therefore, located close to the mills.

The fuel is received more or less irregularly depending upon conditions in the mills, and as the demand of the power station for fuel fluctuates with the load, is therefore readily appreciated that a storage of the fuel is necessary. At the plants in question, wagons deliver the fuel from the mills where they dump it into a hopper from which the fuel proceeds, by means of a steel chain conveyor of type mentioned above, into the top of the storage house. The hopper is provided with a suitable crib to hold back the mixture, thus allowing it to feed properly. A boy is stationed at the hopper and spends most of his time poking the sawdust down by means of a pole so as to make it feed well. It may be surprising to some that this is necessary, but I would say here that cut fuel will not run in a similar manner to wheat, but packs together persistently, making it necessary oftentimes in the fuel house, to use picks in order to make it feed properly into the conveyors. There are at times vertical walls of the fuel thirty feet high in the fuel house. At times, trouble is experienced with sticks mixed in with the fuel, which catch in the chain of the conveyor and tear it apart. Both motor and engine drive are used, about twenty-five horsepower being required to run all conveyors at once, when they are fully loaded.

On entering the fuel house the mixture escapes through openings in the bottom of the conveyor, so located as to allow the fuel to be disposed of properly in the house by dumping it at whatever point is desired. In the bottom of the fuel house is a second system of conveyors which receives the fuel and conveys it into the boiler room.

The boilers at the plant in question are provided with Dutch ovens with holes in the top through which the mixture passes from the conveyor by means of chutes. Extending from the front of the Dutch oven forward, and underneath the conveyor, is a deck on which is stored enough of the mixture to operate the boilers for an hour or so, in case the conveyor breaks down. This insures the continuity of the service while the conveyor is being overhauled, and is a part of the storage scheme. The attendant allows the ovens to be completely filled with the fuel, so as to prevent taking in air at the top. When all of the ovens are filled, the fireman signals the boy in the stock house to stop feeding the fuel into the conveyor. When he again desires fuel, the conveyor is once more started up.

The processes which I have described undoubtedly seem complicated to many present, and easier methods may have suggested themselves. We have in mind, at present, a number of improvements, the principal one being the doing away with the fuel wagon, and substituting therefor a telepher system. This is desirable alone because of the amount of inconvenience the mill people are put to on account of the wagons passing through the crowded mill yards. It has been found by experience along these lines, and the mill people have had a great deal of it, that the chain conveyor with flights is the best method of moving the material from point to point.

I am sure that some members of the convention would be interested in visiting one or more of the large mills, and will add that they will receive a welcome from the mill people, should they care to do so.

Having thus far dealt with our by-product, up to the time it is introduced into the oven, it remains to discuss its value as a steam maker. In this connection, I wish to state that, owing to the limited amount of time available to offer much specific data. What we will attempt, however, is to show that, with conditions such as exist in Portland, there is no fuel so cheap for making steam as is sawmill refuse.

In Station E, the new steam plant of the company, the boilers are equipped for burning oil as well as cut fuel, and it is the intention of the company to make tests in the near future for the purpose of comparing the cost per kilowatt-hour output with the different fuels. Up to the present time, there has been no opportunity of making such a test.

Last fall the Portland Cordage Works made a series of tests to determine the relative fuel values of slab wood, sawdust and oil at their plant. Through the courtesy of S. M. Mears, I am able to give the results of the tests made. The Cordage Company was paying at the time of the tests $1.75 per load for sawdust, $2.25 per cord for slabs, and 82 cents per barrel for fuel oil. The plant was operated during the month of September, 1904, using oil as a fuel. During this month the plant was run 190 hours, with a consumption of 10,000 gallons of fuel oil, at a cost of $191.20, the average horsepower during the period being 142. The cost per horsepower per hour was, therefore, 72/100 of a cent, or 97/100 of a cent per kilowatt-hour. In July the plant operated 296 hours using sawdust as a fuel, 182 loads of 200 cubic feet being consumed at a cost of $318.50. The average horsepower during this period was 250, the cost being 43/100 of a cent per horsepower-hour, or 57/100 of a cent per kilowatt-hour. The excess of the cost of oil fuel over sawdust, as determined by these tests, therefore, amounts to sixty-eight per cent. In August the plant operated 271 hours and consumed 108 loads of sawdust costing $189.00, and 4½ cords of slabs costing $12.38, making a total of $201.38 expended for fuel. The average horsepower for this period was 150, which gives a cost per horsepower hour of 50/100 of a cent or 67/100 of a cent per kilowatt-hour. In May the plant operated 253 hours consuming 147 cords of slabs at a cost of $404.00. The average horsepower during this period was 258. The cost of the fuel per horsepower hour was 62/100 of a cent, or 83/100 of a cent per kilowatt-hour.

In a test made at the Cordage Works to determine the amount of steam required to run the pump and supply the burners, it was found that 8¾ per cent. of the steam generated was used for this purpose.

In the June number of THE JOURNAL OF ELECTRICITY, POWER AND GAS*, is one of a series of articles on Power Plant Economy, wherein Table No. 18 shows the approximate cost of the power at the switchboard when oil fuel is being used. In the table there is worked out the cost per kilowatt-hour output using various sized engines for different lengths of operation and different load factors. It is impossible to make any accurate comparison of the results obtained at the Cordage Works with the figures displayed in this table. I wish to call your attention, however, to the figures as given for a ten-hour per day plant with engines varying in size from 1000 to 2500 horsepower and with a load factor of 33 1/3 per cent. The cost of fuel per kilowatt-hour with oil at $1.00 per barrel varies from 96/100 of a cent to 75/100 of a cent. Oil at 82 cents per barrel, which is the price paid by the Portland Cordage Works, would reduce these figures to $0.0079 and $0.0062.

It will be noted that the cost of operating the Cordage Works with cut fuel compares quite favorably with the general figures given in the table for a much larger plant. When fuel is introduced into the ovens by means of a conveyor, there would be a saving of fuel over stoking by hand.

I am submitting with this paper a number of boiler tests made in using sawdust and slabwood for fuel. From a large number of such tests made at various isolated plants of the Portland General Electric Co., I find that on the

TEST

Made at the Portland Cordage Works, September 26, 27, 28, 29 and 30, 1904, to determine the economy of oil burning as compared with slabwood

	Sept. 26th Two boilers	Sept. 27th Two boilers	Sept. 28th One boiler	Sept. 29th One boiler	Sept. 30th One boiler	Totals
Duration of test—hours	10¼	10⅓	10⅓	10⅓	10½	51¼
Average horsepower	139.33	133.67	138.55	134.41	136	136.4
Temperature of feedwater	218.3	219.3	225	228.36	233.35	224.8
Gauge pressure	83.2	82.1	84.65	85.15	84.65	83.95
Weight of oil consumed, in pounds	4,133	4,136	3,977	4,117	3,170	19,533
Weight of water evaporated, in pounds	50,288	50,693	52,013	53,046	30,606	245,646
Actual weight of water evaporated, per pound oil	12.16	12.23	13.078	12.88	12.557	12.52
Weight of water evaporated from and at 212° per pound of oil	11.14	11.21	12.059	11.87	11.545	11.565

By test made it was found that it required 8¾ per cent. of the steam to run the oil pump and supply the burners. This brings the effective steam down to 10.564 pounds of water evaporated per pound of oil. A cord of dry slabwood will evaporated 11,450 pounds of water, all producing effective work. To do the same with oil, according to the above test, would require 11,450 divided by 10,554, which equals 1084 pounds of oil, which equals 3.226 barrels, at 82 cents per barrel, which equals wood at $2.65 per cord.

average in the neighborhood of 10,500 pounds of water is evaporated with 200 cubic feet of cut fuel and 11,500 pounds of water per cord of dry slabs. Using oil fuel at the Cordage Works one pound of oil was found to evaporate an average of 11.56 pounds of water. Mr. Mears informs me that he has done better recently, after making some alterations in his fireboxes, and that he has obtained as high as 13.25 pounds of water per pound of oil.

I am aware that our members from California are advocates of oil as a fuel, and that it is largely used in electric power plants throughout that State. It has in most cases, I believe, taken the place of coal, and is undoubtedly at the rates at which it can be obtained in California, a much cheaper fuel. In Portland, oil must compete with a by-product of the saw mill, which can be obtained at very favorable rates under long-term contracts.

In conclusion the speaker wishes to state that he regrets that he has been unable to carry out more extensive tests on the value of the by-product of the saw mill as a fuel, being, as are many others, engaged in operation and construction, and well occupied with other matters that are considered of more moment. He trusts, however, that he has made clear to his listeners that by using the saw mill refuse we patronize home industry and at the same time effect a material saving.

TEST

Made at the Portland Cordage Works, December 1 and 2, 1904, to determine the saving effected by new heater, also the economy of oil as compared with dry slab wood.

	December 1st Without heater	December 2d With heater
Duration of test	10½ hours	10½ hours
Average indicated horsepower	140.16	149.85
Temperature of feedwater	219	295.36
Average gauge pressure	84.8 lbs.	85.2 lbs.
Weight of oil consumed	4,277½ "	4,269½ "
Weight of water evaporated	52,123 "	56,594 "
Actual evaporation per lb. oil	12.18 "	13.25 "
Evaporation from and at 212°	12.53 "	12.53 "

Percentage of steam used by pump and burners equalled .056 per cent. This deducted from the amount evaporated from and at 212° leaves 11.83 pounds of water per pound of oil.

In May, 1904, we evaporated 11.763 pounds of water from and at 212° per cord of dry slabs. This divided by 11.83 equals 995 pounds of oil to the cord, or 2.952 barrels at 82 cents equals wood at $2.42 per cord.

TEST

Made at Portland Cordage Works, March 24, 1904, from 7 A. M. to 9:30 P. M., with two intermisssions, amounting to 70 minutes—using slabwood.

Length of run ..... 13 hours 50 minutes
Pounds of water evaporated ..... 100,933 pounds
Slabwood consumed ..... 8 cords
Waste from factory ..... 45 cubic feet
Pounds of water evaporated per cord of wood ..... 12,617 pounds
Average indicated horsepower 262.4
Water consumed, per indicated horsepower hour ..... 29.1 pounds
Average temperature of feedwater before entering boilers ..... 222°
Heated office, tar and drying room ..... 8 hours
Heated factory and hemp mill ..... 2 hours
Pumped oil ..... 13½ hours
Pumped water to tank ..... 4 hours
Pumped water to boilers ..... 15 hours

The slabwood consumed during test was very ordinary in quality, dryness and measurement.

Indicator cards and temperature of feedwater taken every fifteen minutes.

CHAMBER OF COMMERCE BUILDING, PORTLAND, OR.
April 20, 1900.

Steam	Feedwater	Pyrometer	Time Minutes	No. Pounds Feedwater
90	212	406	1:35	424.5
90	179	381	1:50	424.5 424.5
105	150	406	2:00	424.5 424.5
100	200	356	2:15	424.5 424.5
101	200	356	2:30	424.5 424.5
105	180	356	2:45	424.5 424.5
100	172	381	3:00	424.5 414.5
107	194	356	3:15	424.5 424.5
105	188	354	3:30	424.5 213.5
85	190	354	3:45	
988	1765	2156	130:00	6581.5
AVERAGE				
98	1765	361	130.00	13,163.0

A cord of bone-dry fir wood evaporated 13,163 pounds. The above was small and nothing extra for wood.

Reduced to Centennial Standard equals 94.80 horsepower per hour.

CHAMBER OF COMMERCE BUILDING, PORTLAND, OR.
April 20, 1900.

Steam	Feedwater	Pyrometer	Time Minutes	No. Pounds Feedwater
100	210	421	2:00	542 542
100	140	421	2:30	542 542
112	170	356	3:00	542 542
100	180	386	3:15	542 542
90	190	391	3:30	542 542
105	187	436	3:45	542 362
607	1077	2255		5339
AVERAGE				
101	1077	391		H. P. 101.6

Reduced to Centennial Standard, 88.1 horsepower.

Half-dry fir slab wood evaporated 10,678 pounds of water per cord.

Mr. William I. Sturtevant, who has been with The Seattle Electric Company for the past four years, has gone east to assume the duties of Superintendent of Lighting and Power for the railway and lighting properties at Paducah, Ky., the management of which has recently been assumed by Messrs. Stone & Webster, of Boston. The local manager of this company will be Mr. John S. Bleecker, who was also until recently connected with The Seattle Electric Company.

ALTERNATING CURRENT LABORATORY TESTING.

BY GEORGE H. ROWE.

PART III—CONTINUED.

TRANSFORMERS.

Consider the magnetic and electric circuits represented in 65.

P is the primary winding of n_1 turns, S the secondary of n_2 turns. Assume that the magnetic lines passing through coils P and S have a mean length of path through the iron core of l centimeters, the section of which is A square centimeters and permeability μ. Also consider the leakage lines to have mean paths l_1 and l_2 centimeters and sections A_1 and A_2, the permeability being unity. Pass direct continuous current through coil P; then the flux passing through it will be $\Phi P = \Phi m + \Phi L_1$, Φm being the lines through the iron and ΦL_1 being those through the air. In terms of magneto-motive force and reluctance,

$$\Phi P = \frac{4\pi n_1 \mu A i}{10 l} + \frac{4\pi n_1 A_1 i}{10 l_1}$$

From definition, inductance is the number of interlinkages of the turns of the circuit with the flux passing through it when unit current flows in in the circuit. Hence the total flux turns are $n_1 \Phi_p$ and the inductance is $\frac{n_1 \Phi_p}{i}$

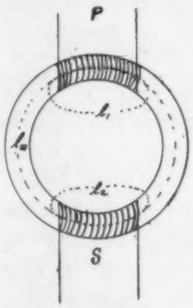


FIGURE 65

Also the mutual inductance is defined to be the number of interlinkages of the second circuit when the first is traversed by unit continuous current. The flux produced by the current in P and interlinked with the second circuit is $\frac{4\pi n_1 \mu A i}{10 l}$, and therefore the mutual inductance is $M = \frac{4\pi n_1 \mu A n_2}{l}$. The self-inductance is defined to be the number of interlinkages of the turns of the circuit containing unit current with the flux which prsses through these turns only. Hence we may write:

$$\Phi_p = \frac{4\pi n_1 \mu A i}{l} + \frac{4\pi n_1 \mu A_1 i}{l_1}$$ or its equivalent.

$\frac{L_p}{n_1} = \frac{M}{n_2} + \frac{L_1}{n_1}$, L_p, M and L_1 being coefficients of total, mutual and self inductance of the primary. Similarly if unit continuous current flows in circuit S we have $\frac{L_s}{n_2} = \frac{M}{n_2} + \frac{L_2}{n_2}$, L_s, M and L_2 being coefficients of total mutual and self induction, respectively, of the secondary.

If now an alternating electromotive force is impressed on the primary P, the relations of the virtual values or maximum values of the various quantities are well shown by diagram as in Figure 66.

Beginning with the secondary current I_1, which is out of phase with the terminal electromotive force $O E_4^1$ by the angle of lag due to reactance external to the secondary coil, we have $O E_2^1$ equal to the electromotive force to overcome resistance of the secondary. The flux due to leakage of the secondary lines is caused by and is in phase with the secondary current I_1^1 acting independently of the primary current. This flux is approximately $\Phi L_2 = \frac{\pi 4 n_2 I_1^1 A_2}{l_2}$. This assumes that the leakage lines are entirely in air and that all leakage lines thread all coils. Neither of these assumptions is quite correct, but each will be considered later.

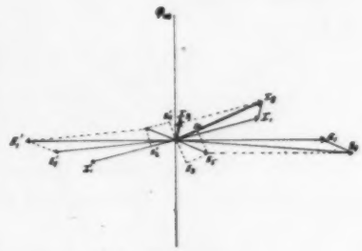


FIGURE 66

The electromotive force caused by the above flux is $-\frac{d \Phi L_2 n_2}{dt}$ and that necessary to overcome it is $+\frac{d \Phi L_2 n_2}{dt}$ and is plotted as $O E_3^1$, being 90° ahead of the current I_1^1.

The flux Φm in the figure is represented by the Y axis. The total induced electromotive force in the secondary will be $-\frac{n_2 d \Phi m}{dt}$ and is represented by $O E_1^1$, being at right angles to Φm.

Having given $O E_1^1$ and the components of $O E_2^1$ and $O E_3^1$ in both magnitude and direction, the component representing the terminal electromotive force will be $O E_4^1$.

For a given current $O I_1^1$ in the secondary, there will be a primary load current $O I_1$ opposite in phase and reduced by the ratio of transformation. It will be seen that I_1^1 and I_1 vary together, and therefore their joint magneto-motive force is zero, or $n_1 I_1 - n_2 I_1^1 = 0$. I_2 represents in direction and magnitude the current which flows when the secondary is open. This current furnishes energy for the iron losses. It is practically constant from no load to full load. The current flowing in the primary when I_1^1 flows in the secondary is made up of two parts, one opposite in phase to I_1^1 and represented by I_1 and the exciting current I_2; the resulting primary current is I_3.

The exciting current is shown in the oscillographic curves (in Figure 67) to be a non-sine wave. It is distorted by hysteresis, as was shown in a preceding article. Analysis shows this current to contain chiefly a third harmonic. Its equivalent sine wave lags behind the electromotive force and leads the flux Φm. This angle of lead of the current in advance of the flux is called the angle of hysteretic lead α. The angle α will depend on the relative magnitude of the two components of the current I_2. The first component is the larger component. It is found in practice by dividing the iron loss in watts by the impressed electromotive force, neglecting the slight impedance drop. More accurately, the value of the energy component is

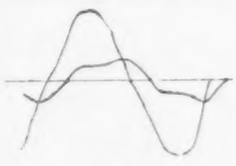


FIGURE 67

$$\frac{\text{Watts applied to primary on open secondary}}{\text{Induced electromotive force in primary}}$$

When the secondary is open the impressed electromotive forces are, however, almost identical.

The second component of the exciting current is called the true magnetizing current. Its value will be found from the equation:

gal 2 rowe

$$\Phi m = \frac{4\pi I_m n_1 \mu A}{10 l}, \text{ or}$$

$$I m = \frac{\Phi m \, l \, 10}{4\pi n_1 \mu A}$$

But Φm is known when the number of turns, voltage and frequency are known from the formula,

$$\Phi m = \frac{E_1 \times 10^8}{4.44 \times \sim \times n_1}$$

and thus B, the flux per square centimeter, is known, and therefore μ. These two components $I m$ and $I e$ will not change from no load to full load; the only change in the main primary current will be I_1, the load current, which varies with the magnitude and phase of the secondary current I_1'. Therefore the resultant primary current will lag behind or lead the electromotive force E_1 depending on the phase of the load current I_1. The leakage flux in the primary and the resistance of the primary will make it necessary to increase the primary impressed electromotive force over and above E_1 by the impedance electromotive force OE_5 in Figure 66.

CALCULATION OF THE LEAKAGE FLUX.

Consider the leakage lines in the particular case shown in Figure 68, through the strip dx wide and l centimeters deep, l being the effective length of punchings perpendicular to the paper. Then the reluctance of these lines will be $\frac{a}{ldx}$, if we neglect the reluctance through the iron part of the magnetic circuit, which will be very small compared with the reluctance of the air path.

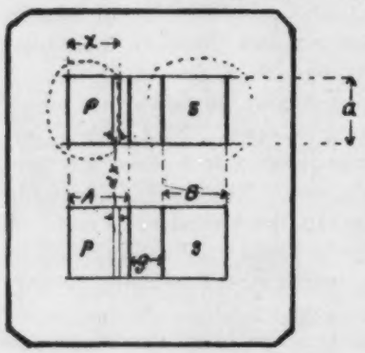


FIGURE 68

The magneto-motive force forcing these lines through the air will be due only to the turns of the primary to the left of the section dx. Counting x from the edge of the window on the left, the magneto-motive force will be $.4\pi I_1 \frac{x}{A} n_1$, and the flux through the strip dx will be

$$\frac{.4\pi I_1 \frac{x}{A} n_1}{\frac{a}{ldx}} = \frac{.4\pi I_1 \, x \, n_1 \, ldx}{A \, a}$$

This flux encircles only the turns to the left of dx, or only the fractional part $\frac{x}{A}$ of the primary turns n_1. Or we can say that $\frac{x}{A}$ part of the flux through ldx passes through all of the primary turns.

Then $d\Phi L_1 = \frac{.4\pi n_1 x^2 \, dx \, I_1 \, l}{A^2 \, a}$

Integrating between $x = o$ and $x = A$ we have

$$\Phi L = \frac{.4\pi n_1 \, A \, l \, I_1}{3 \, a}$$

Similarly $\Phi L_2 = \frac{.4\pi n_1 B l I_1}{3 a}$

The flux between coils will be $\frac{.4\pi n_1 I_1 lg}{a}$, g being the distance between primary and secondary. Therefore the total leakage will be:

$$\Phi L_1 + \Phi L_2 = \frac{.4\pi n_1 I_1 l}{a}\left[\frac{A}{3} + \frac{B}{3} + g\right]$$

The total inductance referred to the primary will therefore be

$$L_{(1+2)} = (\Phi L_1 + \Phi L_2) \times \frac{n_1}{I_1 \, 10^8} \times \frac{.4\pi n_1^2 \, l}{a \, 10^8}$$
$$\left[\frac{A}{3} + \frac{B}{3} + g\right]$$

TRANSFORMER TESTS—IMPEDANCE MEASUREMENT.

By definition the combined impedance of primary and secondary is the electromotive force consumed in primary and secondary resistance and reactance divided by the current.

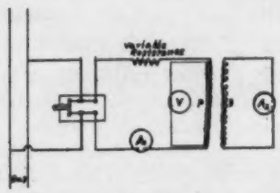


FIGURE 69

Impedance may be measured from either the high or low tension side of the transformer.

Short circuit one of the windings, either the primary or secondary, as shown in Figure 69.

Apply a small alternating current electromotive force to the primary through the variable resistance R until the secondary current, as shown by the ammeter A_2, indicates about its normal full load value. Measure the primary impressed volts by means of the voltmeter V and the current by means of the ammeter A_1. Then the impedence will be $\frac{E}{A_1} = \sqrt{V^2 + X^2}$.

Where $v = v_p + v_s a^2$, in which r_p and v_s are resistances of primary and secondary and a the ratio of transformation. Also $X = x_p + x_s a^2$, being the expression for the reactance reduced to the primary circuit.

The electromotive force above observed is called the impedance drop. It is usually specified as a percentage of full load electromotive force. The frequency should, of course, be the one for which the transformer was designed.

The measurements may be tabulated as follows:

Volts over primary	Current in primary	Current in secondary	Frequency

The impedance is nearly independent of the load, since the flux density remains nearly constant from full load

to no load, and thus the leakage is practically constant.

The impedance drop varies in transformers from 2 to 10 per cent of the working electromotive force. If the primary is wound for 4000 volts the impedance drop may be 200 volts. If the secondary gives 220 volts and the primary short circuited, the impedance volts will be 11 volts, or the same percentage. It will be noticed that the ammeter A_1 measures a small exciting current. On account of the low electromotive force applied, and therefore small density, this may be neglected in comparison with the normal current.

MEASURMENT OF RESISTANCES.

The resistances of the primary and secondary coil may be determined by means ot the ammeters and voltmeter method, using direct current. Both the resistance at room temperature and the hot resistance should be measured. On account of the small resistance of the low tension coils the fall of potential method, comparing with a fractional standard, is recommended.

LOSSES—COPPER LOSSES.

The resistance of both primary and secondary being known, the I_2^2 losses for full load, three-quarters, etc., can be easily calculated: $P F$ = 100 per cent. Or these may be measured together by connection, as in Figure 70.

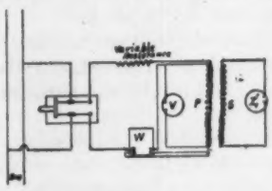


FIGURE 70

The secondary is short circuited through an ammeter I_1^1 and the energy passing into the primary is measured by the wattmeter W_1, the voltage being V. The resistance K is varied until the ammeter I_1^1 shows ¼, ½, ¾, full, 1¼, of full load. The wattmeter indicates the copper loss of both primary and secondary. The wattmeter also measures a small core loss, but since the electromotive force voltage is small compared with normal voltage, the loss is very small. Correction can be made as follows:

Let Wc = core loss at normal volts E; let E_1 = volts applied in the copper loss test. Then the core loss at E_1 will be $Wc\frac{E_1^{1.6}}{E^{1.6}}$

It will usually happen that the correction is unnecessary. Also the wattmeter measures the watts lost in the potential coil of the wattmeter and in the voltmeter. The resistance of these being given this correction is easily made.

Results may be tabulated as follows:

Current in secondary in per cent. of full load	Volts applied to primary	Watts (Corrected)	Speed

Above contains "load loss."

Results may be plotted as in Figure 71.

CORE LOSSES.

The core losses consist of hysteresis and eddy losses combined. These have already been discussed in a preceding section. The hysteresis loss is $Wh = n \backsim B^{1.6} V 10^{-7}$ and the eddy loss is $We = 1.645\ Vd^2 \backsim^2 B^2 10^{-11}$. Since $\phi = \frac{E \times 10^8}{44.4 \times \backsim \times T}$ and since $B = \frac{\phi}{A}$, the number of turns being constant, the densityand, therefore, both the hysteresis and eddy losses will be increased with the frequency, one as the first power and the other as the square.

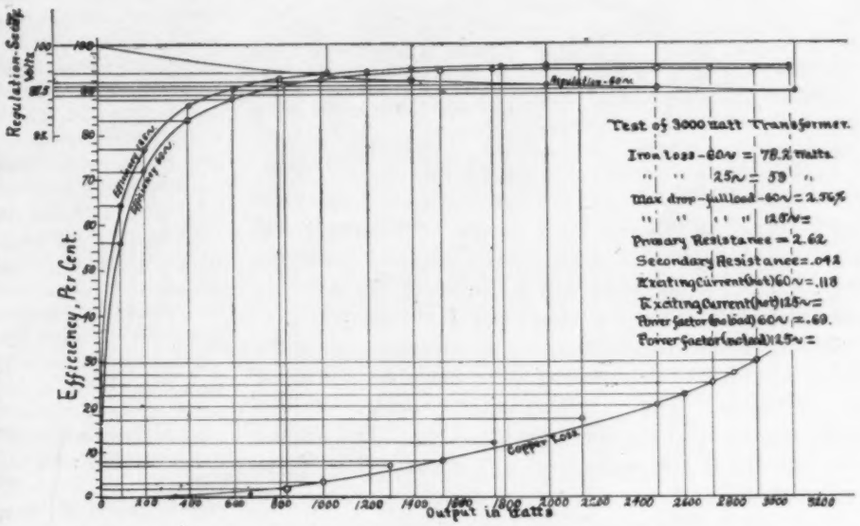

Test of 3000 watt Transformer.
Iron loss-60∿ = 78.2 watts.
" " 25∿ = 59 "
Max drop-fullload-60∿ = 2.76%
" " " " 25∿ =
Primary Resistance = 2.62
Secondary Resistance = .042
Exciting Current (Wat) 60∿ = .118
Exciting Current (Wat) 25∿ =
Power factor (full load) 60∿ = .69.
Power factor (no load) 25∿ =
Efficiency, Per Cent.
Output in Watts
Copper Loss

FIGURE 71

If the electromotive force remains constant and the frequency is increased, the flux ϕ is reduced and therefore B is reduced, thus reducing both hysteresis and eddy losses. A transformer designed for sixty cycles will therefore give less core ioss when operated at 125 cycles, and a transformer designed for high frequency will cost less than one for low for the same percentage of core loss. A transformer designed for high frequency should not be operated on low frequency on account of the high density and therefore large core loss. The thickness of the plates is ordinarily taken at about fifteen mils.

A rise of temperature will reduce both hysteresis and eddy loss.

On the quality of the iron and on the care taken in annealing it after all stamping work is done depends the hysteretic constant η.

It has long been known, moreover, that the hysteresis loss gradually increases with use of the transformer. This phenomenon is called ageing.

In certain especially prepared iron this effect is minimized, although it takes place to a certain extent in all modern types.

The wave form will also affect the core loss. A flat topped wave of electromotive force means a peaked wave of induction B, and therefore a big core loss. A peaked electromotive force wave reduces the core loss. The wave form should therefore be taken, since it may cause a variation of as much as 10 per cent.

For the determination of the core losses connect the instruments as in Figure 72.

These instruments may be made on either primary or secondary, providing normal voltage is applied to either coil, the other coil being open circuited. In the figure is shown a variable resistance for varying the voltage through the range of normal working of the transformer. On account of the influence of this resistance on the wave form it will be better to employ an auto-transformer with sufficient taps. *A* is the ammeter which measures the exciting current and *W* is the wattmeter and *V* the voltmeter.

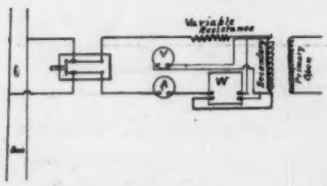


FIGURE 72

It will be seen that here also the wattmeter reads the power used in the voltmeter and in the pressure coil of the wattmeter. The correction is easily made. Also *A* measures the currents passing through the voltmeter and pressure coil of the wattmeter. This correction is also easily made.

Readings may be recorded as follows:

Volts impressed	Watts	Amperes	Speed (Constant)	Temperature of room

Plat as in Figure 73.

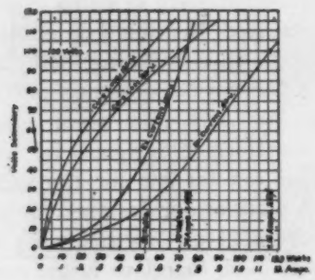


FIGURE 73

(Continuation in next issue.)

REINFORCED CONCRETE CONSTRUCTION.*

BY LEWIS A. HICKS,
Mem. Tech. Soc. Pac. Coast.

THE west, usually first to devise and adopt improved methods, has been slow to apprehend the merits of reinforced concrete, and even when engineers and architects are converts to its advantages, the difficulty in securing intelligent execution of work by reliable contractors, and the lack of standards, both as to specifications and practical methods, has retarded and prevented its use. The fact that it has been largely exploited in this country in conjunction with patented systems of floor construction has also operated to its detriment, for it has been very commonly the case that the commercial licensees of the various systems are not well informed as to the principles of design, and in their efforts to demonstrate the superiority of their own methods have made unwarranted claims which have not tended to establish the material in its proper place in the eyes of intelligent constructors.

Definite information is now available from actual tests in our college laboratories that give us sufficient data to examine the general relations of stress and strain in transverse bending and the application of the simple fundamental principles that obtain with other structural materials are found to furnish rational solution for its problems.

The greatly extended use of reinforced concrete which has resulted from the rationalizing of its design data is amply in evidence from the many illustrations of its construction in the technical press, and from the flood of descriptive matter concerning it.

When the elementary principles of its correct design are within the knowledge of the engineering fraternity, and its phenomena of distortion under stress are known to be reliably reproducible, no argument is required to convince one of its prime importance in the list of materials available for engineering construction.

The factors combining to this result are economy in time and money due to the existence of the great bulk of materials where required as raw products; the possibility of assembling these materials with unskilled labor, by the use of machinery insuring uniform results; the supplementing of defects in the structural character of concrete by the use of small quantities of steel in the form of commercial shapes, everywhere available from stock; the substitution in many places of members of light sectional area, capable of withstanding known stresses to which they may be subjected, in place of heavier gravity sections required for other materials; its high value in fire-resisting and time-endurance characteristics, and, finally, the facility with which it may be adapted to the needs of rapid construction under intelligent, systematic organization.

Most of you will concede its usefulness for dead loads in warehouse, power house and other heavy construction. The latest expert testimony as to its fitness for live loads under the severe conditions of railway traffic is furnished by the report of the committee of the International Railway Congress at Washington, which finds favorably to its use for railway bridge work.

Weak design in this class of work, involving not only economic loss but the safety of human life, would be criminal, and the deliberate judgment of these experts should receive the consideration which their experience warrants.

The question at once suggests itself as to how far this conclusion can be applied to the construction of high buildings, where the conditions both as to property values and the responsibility for life are probably more acute than in bridge work. Here many of you will be dubious as to whether structural steel can be safely replaced with reinforced concrete, and those most familiar with building operations will be openly skeptical.

To examine briefly such data as may be available pertaining to the design of reinforced concrete cage construction is the purpose of this paper.

We will pass over the subject of foundation design, in as much as tension bars have already commenced to replace structural steel, by reason of the saving of time and depths, and because the data used for transverse bending stresses in the design for girders, beams and floor slabs, considered later, may be adapted to foundation work.

The next element to be considered in building work is naturally the design of columns, and the economic statement of the problem is whether we can, without loss of valuable floor space, substitute for steel, which under building conditions carries safe concentric loads of 12,000 pounds per square inch of sectional area, a combination of steel and concrete with a relatively low value of compressive resistance.

The best information available in the literature of the subject has its origin in the work of Considere, but its statement, like that of his conclusion regarding the increase of ductility of concrete by addition of steel, is paradoxical and misleading.

*A paper read before the Electrical Transmission Section of the Pacific Coast Engineering Congress, held at the "American Inn" under the auspices of the Lewis and Clark Centennial Exposition, Portland, Or., June 29-30, 1905.

American experimenters have shown that the apparent increase of stretching power in tension members, which Considere regards as an actual change in the elastic characteristics of the concrete, is merely the distribution of the cracks present over the entire length of the members under stress, so that the total stretch is so subdivided that the cracks are invisible within working limits.

In the same way, the conclusions of Considere on the reinforcement of columns do not offer a complete analysis of the phenomena observed. Summarized, his conclusion is that ultimate column resistance will consist of the sum of the compressive resistance of the concrete, within the windings; the proportionate elastic compressive resistance of the vertical reinforcement and the resistance afforded by the spiral windings, considered by him to be equivalent to 2.4 times as much as would result from the use of the same amount of metal if placed as vertical reinforcement. He also claims that conditions of maximum efficiency exist when pitch of winding is from 1/7 to 1/10 of diameters of winding.

Actual designs range from 2 to 4 per cent. reinforcement, used in hooping or winding, and from 1 to 3 per cent. in verticals, the percentages referring to volume of concrete inside the reinforcement. Using mean values of 3 per cent. for hooping and 2 per cent. for verticals, with a factor of safety of 3.5, recommended by Considere, safe load values of 1000 pounds per square inch result.

When this loading value is applied to design of column for heavy loads in high building construction it will be found that while an economy of cost amounting to 25 to 35 per cent. of steel column costs may be secured, it will be at the expense of loss of floor space. If the earning power of the floor space so lost is capitalized and added to the first cost of the concrete column it will appear that the economic cost of the concrete column is twice that of a steel column performing the same duty.

It follows, as a rough approximation, for heavy loads that safe load values of 2000 pounds per square inch must be realized before concrete columns can be regarded as economically superior to steel. Substantially the same floor space would then be required for both types of columns, and as the first cost of the concrete column would not exceed 50 per cent. that of steel, it is evident that this difference would in time overcome any existing prejudice in favor of steel.

In the minds of many engineers not personally familiar with the actual use of reinforced concrete there would be grave doubt as to the propriety of using as a safe load value such a high figure as 1000 pounds per square inch, and this doubt is reflected in the ordinances which have been adopted by several of our American cities regulating the construction of reinforced concrete. The Cleveland building ordinance, adopted only last year, is, generally speaking, a notable improvement on the ordinances in force elsewhere.

Its provisions relating to concrete columns permit vertical steel members, tied or riveted together, to be filled and surrounded with concrete with an assumed division of stress between the concrete and steel, but finally begs the whole question by requiring that the steel itself, standing free, shall be capable of carrying the entire load, with a factor of safety of three when figured as a latticed column.

It is a common thing in constructed work, illustrated in our engineering press, to see hooping spaced from one to two diameters apart and without evidence of design with regard to the work to be performed.

All of these considerations indicate that present practiee does not warrant such unit loadings as would tend to extend the use of reinforced concrete to column construction in high buildings and we may conclude that unless some further improvement is made in the combinations of the materials there is no danger that the general use of structural steel in this field will be affected.

The writer is not content to accept this as a final conclusion without further investigation, and believes that there are possibilities suggested by the experiments of Considere which give promise of much better results. Some of the prisms of hooped concrete noted by him developed a compressive resistance of 10,500 pounds before ultimate failure, and the character of the failure is not noted.

Some months ago a general outline of some experimental work on full sized columns was agreed upon with Loren E. Hunt, testing engineer for the University of California, which has a testing machine with a range of 200,000 pounds.

Some delay occurred in making up the test specimens, and it was not until May 10th that the concrete filling was placed. We had expected to test them about June 10th, so that the results would be available for this paper, but unfortunately the absence of Mr. Hunt for the summer, and the fact that the testing machine was in need of repairs, have entirely frustrated the object in view. If this could have been foreseen the writer would not have undertaken a paper at this time, but, in as much as it had already been programmed, it has seemed the better apology to give you the reasons which have influenced the undertaking of the experiments.

It is also hoped that any discussion evoked may serve to modify favorably the form taken by the experiments by bringing some new light to the problem.

The phenomena of the molecular resistance to displacement offered by the various substances used in engineering work are but imperfectly understood, and the conventional stress strain assumptions often fail to express all the facts.

As examples of isolated facts, there may be instanced, the fatigue of material; the raising of the elastic limit of steel bars by torsion or reduction of sectional area involving additional molecular displacement, without apparent change in ultimate resistance, and the similar increase of the modulus of elasticity for compression in concrete under successive loadings, well established by a number of observers.

Relatively little attention has been paid by investigators to the lateral distortion suffered by materials under compressive stress involving change of volume, and very little information is available regarding such deformation in other than true ductile materials.

In the test of any material where failure occurs without flexure by pure compression, diagonal shearing forces are produced which tend to cause the molecular structure to distort laterally by the sliding past one another of the particles.

In the case of metals which under ultimate stresses bulge all around normal to the pressure, failure is by convention conceived to have taken place when a stated percentage of distortion in length has been produced, but with natural stones, which are notably weak in shearing and tensile values, actual failure occurs primarily by the spawling out of material in triangular shapes normal on all sides to the axis of pressure followed by actual crushing due to reduction of resisting area and consequent increase of unit pressures. Concrete exhibits the same characteristics as the natural stones. Brick piers also fail by lateral bulging, accompanied by longitudinal shear, which is probably the real cause of failure in all nonductile materials.

It is evident that before failure occurs in a non-ductile material there must be some elastic distortion laterally, and that the strain so produced by a vertical stress may be measured and stated, within the elastic limit, as a definite ratio of the vertical strain produced—within the same limit. It follows that the horizontal stress must be in the same ratio to the vertical stress.

In the case of gases and fluids under pressure there is perfect freedom of molecular displacement, and the full pressure is transmitted laterally to the containing receptable.

With solids, a portion of the pressure is consumed in overcoming what Considere has termed the specific resistance of the material under test, and only a fraction of the pressure reaches the containing receptacle laterally, or is present as stress to produce lateral spawling. It seems probable that in a material of relatively low density, like sandstone or concrete, a vertical readjustment might take place without transmitting as large a transverse pressure as would be the case with such a material as steel.

A tabulation of the value of the ratio between vertical and lateral strains for building stones is given by Wm. H. Burr, without

a statement as to its derivation. Its value varies from 1/11 for certain Oregon sandstone to 1/4 for marble and granite. Steel is stated to have a ratio of 1/2.35. To determine this ratio for concrete is the primary purpose of the proposed experiments.

It was found by Considere in his earlier work that failure of hooped concrete always occurred by bulging of the concrete between the spirals. The pitch of the winding was therefore decreased, and verticals were introduced to further break up the lateral yielding.

If the resistance moment of the verticals to internal bulging is in excess of the tensile strength of the winding, failure occurs by the breaking of the winding and the simultaneous bending outward of the verticals and characteristic spawling and crushing of the concrete.

Such failure under known conditions as to vertical loading and elastic limit of the winding evidently furnishes the data to determine the ratio of lateral strains in concrete at the moment of rupture.

An experiment made by R. F. Dunn is described by Charles F. Marsh in his work on Reinforced Concrete, which indicated internal lateral bursting pressures of about 1/15 of the vertical pressure applied at the ultimate strength of the winding, as determined by independent tensile tests.

This is the only test of the kind within the writer's knowledge where all the conditions are known, and does not, of course, furnish sufficient evidence to warrant the use of this ratio as applicable to concrete generally; neither does it inform us as to whether the ratio is maintained under changing load conditions.

Imagine a steel pipe with walls of such thickness that its distortion, under internal pressure within a stated range would be negligible. Suppose another smaller pipe, of 2″ less diameter, made of the same material except for the center joint, is inserted within the larger pipe and connected at either end so that the outer pipe forms an annular water-tight jacket. Let the center joint in the smaller pipe be made of very thin sheet steel and fill the small pipe with concrete, first filling the annular jacket with water under a slight pressure to prevent the tamping of the concrete from distorting the thin sheet steel portion. Permit the concrete to set, fill the outer jacket with water under a slight pressure to insure perfect contact, connect a pressure gage to the jacket and submit the concrete inside the small pipe to endwise compression. Then will the resistance of the outer pipe, acting through the water and the thin sheet metal, prevent the lateral distortion of the concrete, and the gauge will record the internal pressures transmitted to the outer pipe shell by the water. It would thus be possible to observe the lateral thrust of the concrete for any given vertical pressure within the range of the apparatus.

With this bursting pressure as a known ratio of the unit load to be carried by a column, it is evidently possible to design a pipe of the right diameter to provide the proper sectional area of concrete inside for the unit pressure allowed, and of such thickness as to furnish safe resistance to the lateral thrust, utilizing the usual hydraulic pipe formula.

Mr. Hunt has suggested the testing of such a column, designed with a very small safety factor in the steel, by surrounding it with a water jacket provided with a glass manometer tube of small caliber so that the lateral enlargement under changing loads may be shown visually by the raising of the water in the tube and the displacement, together with the observed shortening of the column endwise, would determine the actual change of volume. Several specimens having diameters of 4, 6, 8 and 10 inches and lengths of 132″ have been prepared, with a steel reinforcement of riveted hydraulic pipe designed for a factor of safety of 5 in the plate, from the simple relation $t=r/100$, which if reduced for rivet inefficiency probably involves an actual safety of 3 against a vertical working stress of 2000 pounds per square inch. The concrete filling is a mixture of 1-3-5 of California cement with Presidio beach sand having 40 per cent. voids, and Niles roof gravel of from ¼ to ½″ diameter and voids of 30 per cent. The ratio of length to diameter varies from 13 to 33, and as no provision for flexure was made, some of the columns will undoubtedly fail in that manner.

The introduction of symmetrically placed vertical bars against the pipe wall on the inside will evidently take care of bending moments induced by flexure or eccentric loading, and will also serve to distribute any local tendency to internal shear. For ordinary building story heights this would not be required.

The writer questions whether the addition of vertical reinforcement without hooping really adds to the effective strength of concrete columns, for, in as much as the failure of the concrete has been shown to be in longitudinal shear, and the steel bars have no transverse bending strength, it seems apparent that the critical point would be the lateral yielding of the concrete from shear parallel to the axis of pressure. Believing this, the writer regrets that such a doubtful method of reinforcement has been adopted by Considere as the measure of value of so reliable a material as hooped concrete. On the other hand, if lateral yielding is prevented and the ratio of length to diameter is within flexure limits, and the modulus of elasticity within the reinforcement is increased by successive loadings until it approximates that of granite, there appears to be no other limit to the compressive resistance of the column than the final bursting of the reinforcement. It seems probable that the ratio of lateral to vertical strain may increase as the modulus of elasticity increases, so that the bursting pressure will not continue in the same proportion to the loading, and a limit may be reached much sooner than would be indicated if the Dunn ratio were a constant; but in any case the placing of the limit is evidently within the power of the designer when experiments have determined the actual behavior of the material under such conditions.

The theoretical and practical advantages afforded by the suggested form of reinforcement offer strong arguments in its favor. Inasmuch as the concrete outside the hooping has no structural value other than fireproofing, it is evidently not important that the concrete within and without the reinforcement should be connected. Fireproofing may be applied to pipe reinforcement, with light wire hoops to prevent cracking, in the same manner as to ordinary steel columns, either at the time of construction or afterward.

One of the common methods employed in building spirally wound columns has been to assemble the component parts for a story height in the shop, placing the vertical bars symmetrically in the winding, and tying them together thoroughly, so as to permit transportation and placing without disarrangement. Part of the verticals extend through above the floor level to anchor the next additional length, and four of the rods are commonly bent out at right angles to anchor the beams and girders intersecting at the column. Because of the bending down of these rods the winding usually extends from the floor to the ceiling line only, where the bending commences, and the concrete intervening between that point and the next floor line lacks continuous protection against lateral and vertical loading of 1000 pounds per square inch by the column within the reinforcement.

It is then in much the same condition as if a loaded column were placed directly on a concrete pier, without a shoe or base.

In the case of a pipe column, continuous protection is secured from the shoe on which it rests to the highest roof load imposed. At junction points the tension and shear rods of the girders and beams would be slotted through the continuous pipe, with a loose hoop placed outside the pipe, both below and above the point slotted, to make up for the strength loost in the pipe.

Reinforced concrete beams as usually designed have a sufficient area of steel in the tension bars to provide for vertical shear without considering the concrete, but where this is not the case short shear rods may be inserted through the column walls to support the beams with loose hoops as above described.

It is apparent that the placing of the reinforcement as a pipe greatly simplifies and expedities the work of construction when compared with the handling of a mass of spiral winding which

has every chance of displacement from its proper position at the hands of the tamper.

Assuming the correctness of the Dunn ratio, the percentage of steel required for safe loading of 2000 pounds per square inch in the form of riveted pipe would be only 2 per cent. of the volume of concrete, as against 3 to 6 per cent. recommended by Considere for spirals and longitudinals.

The considerations discussed contemplate only the use of the concrete within the reinforcement for compressive resistance and dependence on a thin exterior steel pipe in tension only for transverse internal stresses. There is a further possibility of reducing sectional area of columns for extreme cases by increasing the thickness of pipe wall and loading it in compression as well as the concrete but the writer feels that it is useless to go further at present than to suggest lines for investigation and experiment which seem to warrant hope of practical results.

The determination of the modulus of elasticity for concrete by experimenters has so strongly reflected the uncertainties of the personal equation involved in mixing and other variables, as shown in resulting values of from 1,500,000 to 7,000,000 inch-pounds, that there is some natural hesitation in applying the results obtained to actual designs, where the equation of the man with a shovel is introduced and mathematical refinement of treatment is evidently out of place.

The experimental work of Professor Talbot and Professor Turneaure has furnished evidence that the position of the neutral axis in a reinforced concrete beam when stressed to its ultimate value approximates closely to a distance of .6 of the depth of the beam above the center of gravity of the steel reinforcement. Professor Talbot has given an empirical expression for the position of the neutral axis, based on experiment, as a ratio of the depth of the beam below the compression face, viz:

$$k = 0.26 + 18p$$

This expression may be used for final determination on exceptionally important designs, but for usual percentage of reinforcement, and within allowed working stresses, it is probable that the error introduced in assuming its position at $.4d$ below the compression face will be of much less relative importance in the result than a mistaken selection of a value for the modulus of elasticity not conformable to the actual conditions obtained in construction, and preliminary computations are much simpler by regarding its position constant.

The area of the diagram of compression stresses above the neutral axis representing the product of the maximum fiber stress and its distance from the neutral axis to the upper compressive face will vary from one-half to two-thirds of the rectangle within which its boundary line of ordinates representing fiber stress is described, and the center of application of the sum of the compressive stresses will be above the neutral axis from five-eights to two-thirds the distance from said axis to the upper compression face. For practical designing the position of the centroid of compression is assumed to be above the neutral axis a distance of .66 of the total distance to the compression face. Adopting the following notation, viz:

Let b = width of beam
d = depth of beam from center of gravity of steel reinforcement to upper compression face
p = ratio between sectional area of steel and concrete
Cw = working stress in concrete
Sw = working stress in steel
As = area of steel
M = bending moment in beam

Consider a reinforced concrete beam of unit width. Since the sum of the forces on either side of the neutral axis must be equal, and since $As = p \times d \times l$, we may write, neglecting tension in the concrete,

(1) $Cw \times .4d \times .666 = Sw \times pd$, or $p = .26\ Cw/Sw$

It will be observed that for given working values of safe stress in the concrete and steel there is but one percentage of reinforcement which will preserve an economic balance. It is desirable that the concrete should not be stressed in compression to more than one-fourth of its ultimate, while there is no reason why the steel, if adequate provision for adhesion is made, should not carry the same unit stresses allowed for similar grades of material in structural steel work.

It therefore appears more rational to develop formulae in which actual allowed unit stress values may be inserted, rather than to calculate ultimate strength of the combined material and affect the result by a factor of safety common to both.

If loading permits less steel than the economic percentage in a beam of given dimensions, the compression in the concrete may be neglected, since the safe loading of the steel will not develop its safe stress. If, on the other hand, more steel is required than indicated by the economic percentage, some provision other than the concrete itself will be required to keep the stress in the concrete within its assigned limits. If values adopted in the ordinances of some of our American cities are used in design, viz:

Safe compression value for concrete, 500 pounds per square inch.

Safe tensile value for steel, 16,000 pounds per square inch and a good grade of concrete, mixed 1-1-2-4, is used in conjunction with commercial bars and rounds of soft steel having an elastic limit of 33,000 to 40,000 pounds, it is evident that failure will occur in the tension side long before the ultimate compressive value of the concrete is reached. Most of the experimental results confirm this, failure usually occurring from an extension of the first visible crack in the tension side of the beam, which takes place at about two-thirds of the ultimate load sustained.

The elastic limit of such bars of commercial steel as have come under the personal observation of the writer has ranged from 36,000 to 44,000 pounds, and for the working stress of 16,000 gives an average safety factor of two and one-half in steel.

If the mixture of concrete is modified to give an ultimate thirty day crushing value of 2400 pounds, and one-third of this adopted as working stress for concrete, there will be a more nearly balanced condition, and the economic percentage will be

$$p = .26\ \ 800/16000 = 0.0125$$

in place of about .008 per cent. called for by limiting the stress in the concrete to 500 pounds per square inch.

The most economical method of increasing the strength of a beam of given sectional area is evidently to enrich the concrete mixture, as this not only permits higher working stresses in compression, but within working limits has a favorable influence on the condition of the concrete below the neutral axis.

The effect of placing steel on the compression side of a beam is not well determined, but some experimenters have reported that no increase of strength is obtained by such disposition of metal. The writer believes that the reason for this is the same previously noted in connection with the use of vertical bars in columns without hooping, viz: that longitudinal shearing takes place before the bars develop their compressive strength. If this is correct, the remedy would be the use of stirrups at much more frequent intervals than is usually customary.

This problem of obtaining maximum strength from members of limited depths is a constantly recurring one in building design, and although reinforced concrete girders are being constructed with steel in the compression side under moments which indicate that the steel must be supplementing the concrete, the writer would not place reliance on steel so placed without further experimental knowledge. It seems probable also that Considere's results with hooping of columns may be applied to beams with good results.

Illustrating the comparative weakness of reinforced beams, it may be stated that the modulus of rupture for pine beams for center breaking loads is $500\ bd^2/L$, while the same quantity for concrete beams, reinforced with 1.25 per cent. of high steel having an elastic limit of 60,000 pounds, would be about $200\ bd^2/L$. Or, in other words, the strength of pine beams is from two to four times greater than for reinforced concrete of the same depths and spans.

This phase of design needs further investigation before special conditions existing on high building work can be successfully met.

Since the limiting conditions of allowed compressive stress are included in the determination of value of p from equation (1), we may not obtain an expression for the depth in terms of the known bending moment and allowed steel stress.

The tension in the steel is evidently equal to the quotient raising from the division of the bending moment by the lever arm of the resistance moment of the beam.

This lever arm common to both the forces above and below the neutral axis will be the sum of the distances from the neutral axis to the center of gravity of the acting forces in the steel and concrete, or.

$$6d + (4d \times \tfrac{3}{8}) = .85d$$

We may now equate the forces acting below the neutral axis as found in equation (1) with this expression for tension in the steel and solve for d as follows:

$$(2)\ Sw\ pd = M/.85\ d \text{ and}$$

For beams of any width this may be written

$$(3)\ d = \sqrt{\frac{.85\ Swp}{M}}$$

$$(4)\ M = (0.85\ Sw\ p.)\ bd^2,$$

a general equation which may be used for any possible safe or ultimate stress in either concrete or steel, for any percentage whatever of reinforcement. The terms 0.85 Sw will give results agreeing closely with experiment between the limits of ½ to 1—¾ per cent. of reinforcement when the elastic limit of the steel is used in place of the working stress. Outside these limits the variation in position of neutral axis and resulting changes in length of lever arm about the center of gravity of the compressive forces necessitate more precise determination of these factors, although the continued use of the constant 0.85 will not involve errors of more than 10 per cent. in excess for 2 per cent. reinforcement, and above 6 per cent. in deficiency for .001 per cent. reinforcement.

Using Talbot's experiments, the relation expressing the variation in length of lever arm under changing conditions of reinforcement may be derived as follows:

$$r = \text{Lever arm} = .90 - 6.5\ p.$$

and this resulting value may be substituted in equation (4) in place of the term 0.85, which is evidently correct for a reinforcement of about 1 per cent.

European engineers have derived a formula for strength of concrete beams in the form

$$M = \mu\ bd^2$$

and many foreign experiments have been tabulated in the form

$$\mu = M/bd^2$$

which furnishes a convenient comparison of the relative strength developed by different beams tested. Such tabulations have no value, however, when the characteristics of the materials are lacking. It will be observed that the formula offered by the writer can be written in the same form, and yet furnishes an analytical working conception of the results of changing percentage of reinforcement.

In this country, T. L. Condron has derived a straight line formula from the Talbot and Howe experiments, and Professor Hatt has recently published a similar formula expressing the average results obtained from work at Purdue University. The following table gives the comparative results obtained from the Condron and & Hatt formulae for the value of the expression M/bd^2, together with those from equation (4).

TABLE I

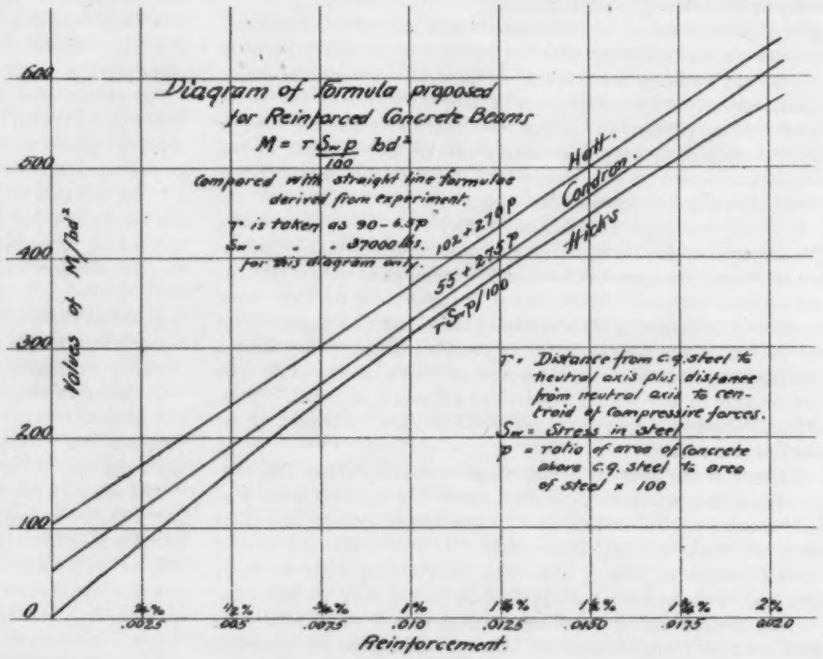
Reinforcement percentage	.001	.003	.005	.010	.015	.020
Hatt $102+260\ p$	129	183	237	372	507	642
Condron $55+275\ p$	82	133	193	330	467	605
(4) Hicks $0.85\ Sw\ p$	31	94	157	315	472	629
(5) Hicks $r\ Sw\ p$	33	98	161	311	444	570

The last line is computed with the corrected value of length of lever arm, r, for each percentage, and shows the influence of the lowering of the neutral axis with increased areas of metal in the beams.

For reinforcement of 1 per cent. and upward the results of equation (5) $m = (r\ Sw\ p)\ bd^2$ conform more closely to the Talbott experiments than the straight line formulae, but for the smaller reinforcements the writer is unable to offer any rational explanation for divergence in results.

The first term of the straight line formulae is defended by the fact that in plotting the experimental values of M/bd^2 the results from bars of widely differing elastic characteristics appear to intersect the line of zero reinforcement at a common point above the base, and this point approximates the coefficient expressing the strength of a plain concrete beam.

If tensile strength in the concrete is neglected, as it should be for ultimate values, it hardly seems proper to use such a term. On the other hand, if equation (5) is plotted it will be found to be a curve originating at zero values and approximating rapidly to a straight line up to 1—½ per cent. reinforcement, where it commences to sag below the straight line, reflecting the observed facts of experiment in this respect. It is probable that it would be impossible to determine experimentally sufficiently precise values o



M/bd^2 for very small ratios of reinforcement to definitely locate the curve near its lower extremity. Nor is it of any great importance to do so, since thermal considerations and the distribution of local defects in the concrete suggest the use of more steel in any beam section than would be indicated by these extremely small percentages.

The reverse is, however, true at the other end of the curve, where, if a straight line formula is used by persons unfamiliar with its derivation, there is certainty of introducing dangerous values by extending its application beyond the range intended by its authors, while the formula suggested in the form of equation (5) is shown to give results which agree as closely with experiment below 1—½ per cent. reinforcement as the straight line formula, and above that point separates from it and continues in agreement with experiment.

The simple equation proposed, when modified to conform to change in loading, may be adapted in the usual manner to all the bending problems which arise in practice. This ground has been so thoroughly covered in numerous books and professional papers that it would be a waste of time to incorporate such matter here.

The writer merely wishes to call attention to the question of

enclosure, which properly falls into the category of "bending."

In cage construction the existence of wall girders and columns furnish ideal conditions for the use of light reinforced concrete curtain wall tied in all directions into the skeleton frame. The maximum wind load, for the spans which occur, are insignificant compared to floor loads, and the saving in weight is important.

Front elevations and other walls receiving architectural treatment may be faced with any building material now in use, with a much more thorough bonding than is now considered necessary for a pressed brick front.

It is possible to lay up the facing, tied with wire to a back form to insure alignment, and back up with reinforced concrete as rapidly as the brickwork progresses, in such a way that the resulting combination, while saving weight and space, is much better adapted to resist the bending moment of architectural projections than ordinary brick enclosure.

All exterior walls should receive the same treatment as to damp roofing or furring required by other masonry walls.

The most important factor in the compressive strength of concrete is the void space of the sand used, since this determines the amount of cement required for unit volumes of mortar of equal strength. If the voids of all materials entering into the composition of concrete, smaller than some agreed limit, such as 1/16 inch maximum dimensions were always measured and stated, the value of comparative tests would be greatly increased. Without this information it may often happen that a nominal 1-3-6 mixture may show greater strength than a 1-2-5 composition. Suppose the first to be made up of Niles sand with a void space of 30 per cent. indicating the presence of more than sufficient cement to fill the voids, a condition requisite for the best results, and that the resulting volume of mortar is mixed with crushed rock having voids of 45 per cent. indicating rather fine sizes. Again, there is an excess of mortar—a condition which facilities handling and workmanship.

Suppose the second mixture to be composed of beach sand, having a fine, uniform grain and void space of 58 per cent. showing a deficiency of 16 per cent. in amount of cement required to fill the voids, and a total deficiency in comparative strength of 28 per cent. There is a further deficiency in the amount of mortar present to fill the 45 per cent. of voids in the rock used with both mixtures, and a probable net loss of strength, to the extent of 30 per cent. in ultimate compression values when compared with mixture No. 1. Nor does this represent the worst aspect of the case.

Mixture No. 1 would produce about seven cubic feet of tamped concrete in the wall for each foot of cement used, while No. 2 would not make more than five cubic feet.

At present prices of cement in California this would mean that a cubic foot of 1-2-5 mixture would cost 3 cents more, or about 12 per cent. in excess more, than for the 1-3-6 mixture, although its virtual value relatively would only be 60 per cent.

Furthermore, since design is based on the application of safety factors to ultimate values obtained from test specimens, it is apparent that the discrepancies in results obtained from lean and rich mixtures by different observers, and the low values shown by numerically rich mixtures with bad void relations, tend to the adoption of low working values, and thus bring about the use of larger quantities than would be required for the duty assigned it, if the real strength was within the knowledge of the designer.

Formulae have been proposed for the ultimate compressive strength of concrete of differing makeup of aggregate in which neat strength of cement is the maximum to be reduced by a constant multiplied into the ratio between volume of cement and aggregate, as follows:

$C=4500-250f$, where f represents the volume of aggregate divided by the volume of cement.

Applying it to the cases already noticed, ultimate values are obtained as follows:

Mixtures..... { No. 1—1-3-6=2250
No. 2—1-2-5=2750

The expression $4500-6000\ V$, where V equals the percentage of void space in the sand used smaller than 1/16-inch diameter, applies in making comparisons between mixtures having the same makeup in terms of quantities but a different void space in the sand used. The writer believes this to be the logical form for such an expression, and finds that it covers a limited range of experience in our own work with California sands.

We have tested all the sands and quarry products within freight limits of San Francisco, and find that while quarry products show a marked similarity for the same grades, there is a wide variation in the characteristics of sand and gravels.

Good results can sometimes be secured by blending sands from different localities, as the resulting void space of the combination is not always the average of the sands considered separately.

There should be an authoritative determination of the question of comparative compressive strength, and it seems apparent that while a 1-2-4 mixture will be slightly stronger than a 1-2-5 having the same materials, a much more important gain in strength may be secured, with direct saving of money, if another sand having a smaller void space can be substituted.

Concrete has been shown to have about the same characteristics in shear as in the natural stones, and the ultimate value for shear approximates 1/10 of the ultimate for compression.

Where a mechanical bonding is not secured between concrete and reinforcing steel by means of deformation of the bars, the shear between the steel and concrete becomes an important matter for investigation in any proposed design.

Statements of the value of adhesion vary from 200 to 700 pounds per square inch of contact. For one-inch plain round bars this would indicate a minimum shear of 7500 pounds per foot, and would mean that a length of twenty-six inches would develop the safe tensile stress allowed in the bars, and for lengths usual in practice the factor of safety for adhesion will equal span in inches divided by twenty-six.

Inasmuch as the strength of bars of smaller size decreases as the square of the diameter while the shear decreases only as the diameter, it is evident that the smaller bars involve larger factors of safety and a better distribution of stress.

In buildings where the height or value of floor space does not limit the space available for columns, reinforced concrete may be used economically in place of steel in combination with girders and beams of the same material within such limits as the available depths and allowable compressive strains in the richest concrete mixtures used permit.

For extreme cases of concentrated loads in long spans of limited depth it is probable that resort must be had to light structural shapes of steel in both tension and compression to insure positive connection between the acting forces, independent of the concrete, except as to the useful function it still performs as a buckling or stiffening element.

Further investigation as to the design of both beams and columns is desirable before the material can be rated as acceptable in all cases.

PERSONAL.

Mr. H. F. Stratton, who has been connected with the principal office of the Electrical Controller and Supply Company, at Cleveland, Ohio, has accepted the position of New York representative of the same company, with offices at 136 Liberty Street, New York City.

Mr. Otty Wakeling, who has been for the past year salesman and engineer for Baker and Hamilton has been promoted to manager of the machinery department. Mr. Wakeling is a graduate of McGill University, Montreal, Canada, and the rapid promotion he has attained speaks well for his business ability.

Mr. H. S. Shelton, who has for several years been connected with Baker and Hamilton, of San Francisco, as manager of their machinery department, leaves October 1st for Portland, Or., where he will engage in business for himself, the new firm will

be Monroe and Shelton, boilers, engines and machinery, 212-214 Front Street.

Mr. Robert Mc F. Doble, consulting engineer, of the Abner Doble Company, San Francisco, has returned from a trip of several months through the Sierra Madre Mountains on the west coast of Mexico and also in Colorado, where he was engaged in making examinations of several important hydro-electric long distance power projects.

Mr. Arthur Geisler, chief engineer of the Platt Iron Works, of Dayton, O., after having spent six months in Europe, visiting the principal power plants of that country, is now in San Francisco on his way through the West and Northwest inspecting the numerous plants that his company have installed. Mr. Geisler is one of the recognized authorities on pumps and engines. He will remain in San Francisco about three weeks. He will then visit Seattle to inspect that engineering wonder in water wheels, they installed at Snoqualmie Falls. It is a ten thousand horse-power water wheel unit.

Mr. W. S. Doran, formerly associated with The British Westinghouse Electric and Manufacturing Company, (Ltd.), has just been appointed manager of the power department of the Allis-Chalmers Company, in which capacity he will have complete charge of the company's commercial affairs pertaining to reciprocating steam engines, steam and hydraulic turbines, condensers, gas engines, blowing engines for iron and steel blast furnace, service and rolling mill engines, with headquarters at the general offices of the Allis-Chalmers Company, Milwaukee, Wis.

MR. W. S. DORAN

With his thorough training and varied experience, Mr. Doran is pre-eminently qualified to carry on this large and important work. He brings with him not only the knowledge acquired in some of the larger manufacturing concerns in this country, but also the wide scope of technical training gained during the many years he has spent abroad. He started his business career with the Southwark Foundry and Machine Company, Philadelphia, where he remained for five years engaged in drafting and general shop work. After spending some time with the United Gas Improvement Company, of Philadelphia, in the construction and management of water gas plants he became connected with Henry R. Worthington, with whom he remained for many years, having headquarters in New York, Chicago and Philadelphia, being largely occupied in negotiating with the United States Navy for pumping plants for war vessels. In addition to his engineering duties, he had charge of the branch offices, and while located at Chicago had complete charge of their entire Western business. In 1899 he joined the Worthington Pumping Engine Company (Ltd.), with headquarters in London, England, where he took charge of their various branch offices and the important negotiations in Great Britain and Ireland. In 1901, Mr. Doran became associated withThe British Westinghouse Electric and Manufacturing Company (Ltd.), and since then has been establishing their branch offices and supervising their sale department. In that capacity he has successfully conducted a large number of important negotiations with steam railway companies, power distribution companies and street railway lines.

LITERATURE.

"The Letter of Petrus Peregrinus on the Magnet," A. D., 1269, translated by Brother Arnold, M. Sc, Principal of La Salle Institute, Troy, with introductory notice by Brother Potamina, D. Sc., Professor of Physics in Manhattan College, New York. McGraw Publishing Company, New York; Price $1.50; forty pages. The translators have done a good work in making available in modern form an old document that is historically important. It is preceded by a scholarly introduction and followed by several pages of early references to the mariners compass. It is a beautiful example of the printers and binders art.

"Electric Railways, Theoretically and Practically Treated," by Sidney W. Ashe, B. S. D. Van Nostrand Company, New York; price, $2.50; 295 pages. A very timely book which has brought under one cover much data that has heretofore been available only in scattered form. It is brought well up to date on American practice, and describes both direct current and single phase motors as applied to traction. It will prove useful both as a text book and as a reference work.

"Wireless Telegraph, Its History, Theory and Practice," by A. Frederick Collins. McGraw Publishing Company, New York; price, $3.00; 300 pages, illustrated. A most excellent volume on a very live topic. It treats the subject fully both historically and gives descriptions of various commercial systems. It is entirely free from the trade catalogue features that are so prominent in many technical works, and foot note references to authorities add largely to its value. It is the most valuable contribution to the literature of the subject on which it treats that has been published to date.

"Geology of Western Ore Deposits," by Arthur Lakes. The Kendrick Book and Stationery Company, Denver, Colo.; price, $2.50; 438 pages; second edition. The first edition of this book was published a number of years ago, and the present edition is very much enlarged, and practically rewritten, and brought up to date. The treatment is both general and applied to particular localities. In the treatment of localities Colorado occupies the major portion, but excellent chapters deal with Tonopah and Goldfield, and Alaska receives a fair share of attention. The book is of convenient size and neat appearance, and is worthy of a place in the library of every person who is interested in mining.

"Hand Book of Tables for Engineering Calculations," by Richard C. Powell and William E. Hawley, assistants in physics and members of the Handbook Committee of the Associated Electrical and Mechanical Engineers at the University of California. Issued from the Standard Press, Berkeley, Cal. A volume of 104 pages bound in semi-flexible covers. The presswork and appearance are good, and the book contains in handy form various tables, physical constants, and formulae, most frequently used in engineering computations. Price, $1.00.

"Short Course in Alternating Current Testing," by Fitzhugh Townsend. D. Van Nostrand Company, New York, 1904; 32 pages; 5½ x 8½; board; price, 75 cents. This book, descriptive of a laboratory course given at the Columbia University, describes in a clear style a series of tests which may be applied to alternating current machinery to bring out the characteristics of each kind of apparatus and gives the results to be expected and reasons. The tests while of laboratory character are written with commercial practice in view and show therefore interest practical men. The mathematical treatment is simple though presuming that the reader has a knowledge of the theoretical elements. Ten clear diagrams illustrate the text.

The Wagner Electric Manufacturing Company, St. Louis, Mo., in their Bulletin, No. 72, have given to the public very valuable information on the subject of Standard Lighting Motor Transformers, their operation and their construction. This bulletin may be had for the asking from any of their agencies or direct from the home office.

The Allis-Chalmers Company, Milwaukee, Wis., has a very neat Bulletin out for August, No. 1600, on the subject of Pumping Engines, giving a test and record of a thirty million gallon pumping engine.

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EDITORIAL.

GAS AND ELECTRIC MERGER.

The following circular was issued by the directors of the San Francisco Gas and Electric Company on September 18th:

To the Stockholders of the San Francisco Gas and Electric Company: Messrs. N. W. Halsey & Co., bankers, have offered on behalf of a company, to be organized by them, $90 per share for all or not less than two-thirds of the issued stock of the San Francisco Gas and Electric Company, payable $25 per share in cash and $65 per share in 5-per-cent. thirty-year general mortgage and collateral trust gold bonds of such company. These bonds are to be secured by a first lien upon all shares of the San Francisco Gas and Electric Company acquired and by a first lien upon all the shares of the California Gas and Electric Corporation acquired by the new company, but in no event upon less than four-fifths of the issued stock of the California Gas and Electric Corporation. The entire issue of such bonds is to be devoted only to the acquisition of the stock of the San Francisco Gas and Electric Company. The Union Trust Company of San Francisco is to be trustee for the bondholders. The bonds and mortgage will be drawn under the supervision of a committee which has been appointed to represent the various interests. The salient provisions of the mortgage have been approved by the undersigned and agreed to by the purchasers. A sinking fund of $250,000 per annum, beginning with the first year, is to be paid by the new company to purchase and retire bonds at a price not to exceed $1050 per bond and accrued interest.

An agreement has been made and lodged with the Union Trust Company of San Francisco, where it may be examined by the stockholders. Messrs. N. W. Halsey & Co. have deposited with the Union Trust Company of San Francisco $500,000 to secure their performance of the agreement. Under the agreement (if all the stock is deposited) approximately $4,000,000 is to be paid in cash. As the bonds for the remainder of the purchase price are to be secured by all the shares of stock sold, and in addition thereto by at least 80,000 shares of stock of the California Gas and Electric Corporation (now quoted at $80 per share), and as the mortgage will contain stringent provisions for the maintenance and preservation of the security, in our opinion the bonds should be worth par, and we shall deposit our stock with the Union Trust Company of San Francisco, to be delivered to the purchaser upon payment of the purchase price as stipulated in the agreement. All other shareholders who desire to avail themselves of the offer may deposit their stock with the stock company (and sign the agreement) on or after September 20, 1905, against which they will receive negotiable receipts. Unless two-thirds of the issued shares of the company shall be deposited on or before the 15th day of November, 1905 (or within such further time, not exceeding thirty days, as the committee may allow), the offer may be withdrawn.

If this deal is consummated the two largest corporations on the Pacific Coast engaged in the production and sale of gas and electric power will be brought under a common control.

Numerous efforts have been made in the past few years to effect a combination of the extensive interests of the California Gas and Electric Corporation and the San Francisco Gas and Electric Company.

The former, whose present extensive business had its beginning in a small hydro-electric plant installed on the South Fork of the Yuba River in 1895, now controls practically the entire gas and electric output of that portion of the State from Fresno north to Red Bluff, with the exception of San Francisco.

It has gradually acquired the local plants in the various cities and towns and has erected large hydro-electric plants, has purchased and consolidated others, and by its liberal and broad-minded policy has developed its business where its gross income for the year 1905 will equal, if not exceed, $6,000,000.

It has for a number of years been the ambition of the controlling spirits in the California Gas and Electric Corporation to absorb the San Francisco market. They were wise enough to realize that this could not be accomplished by invasion of a territory occupied by such a powerful and well-established rival as the local company, except after a long protracted struggle, which in the end could only have been settled by a compromise.

During the last couple of years of the operation of the Independent Electric and Gas Companies by Mr. Claus Spreckels there were times when it seemed possible that the California Gas and Electric Corporation might enter the field as the ally of one or the other of the competing factors. When Mr. Spreckels sold out his interest the control of the local field passed into the hands of what has always been known as the "Old Company."

Stimulated by reasonable and low prices, the consumption of gas and electric power in San Francisco has continued to grow with a rapidity that has taxed the efforts of the San Francisco Gas and Electric Company to keep pace with.

The net earnings were heavy and were such as to permit the payment of dividends at the rate of 5 per cent. on the par value of the stock, besides taking care of extension and maintenance of the plant.

In spite of these facts, the market price of the stock for the two years following the purchase of the Spreckels plants fluctuated from $55 to $60 per share.

It is possible that this was in a measure due to a feeling that such a tempting market must sooner or later

lead to bringing to the city transmitted power from some water power source.

A number of water power developments have been projected, some chimerical and others having a more or less substantial basis, and all claiming to consider San Francisco as a tributary market.

The feeling of uneasiness on the part of the investing public was probably not quieted by the contract negotiated about a year ago, whereby the California Gas and Electric Corporation is to commence to supply the United Railways of San Francisco with power to operate its street car system on January 1, 1906.

This contract led to the construction of a large gas plant just across the boundary between San Francisco and San Mateo counties, primarily intended to supply gas for large gas engines to drive electric generators to back up the transmission lines. This plant occupied a strategic position quite comparable to that of a large fortified military post near the boundary between two countries.

Whether the facts cited above were factors in leading to the deal by which the two companies are being brought together is purely a matter of conjecture. They probably had some weight in leading the parties at interest in the San Francisco Gas and Electric Company to accept the terms finally offered. These terms are that the stock of the San Francisco Gas and Electric Company is to be purchased on a basis of $90 per share, $25 to be paid in cash and $65 in bonds secured by the stock and properties of the two companies.

Rumors and counter-rumors have been in circulation as to the inclusion in the present deal of the Mutual Electric Company and the San Francisco Coke and Gas Company, but at the present writing nothing definite on this score is known to the public. Neither of these companies have plants of sufficient size to be heavy factors in the situation at the present time, although they would form a nucleus from which serious competition might be developed.

It is not definitely known who the parties are that will control the combination nor what interests they represent. If the policy which has governed the past dealings of the California Gas and Electric Corporation with the public are followed out in the new and broader field the community will not suffer, and capitalists who are invited to invest in the securities of contemplated competing companies will be apt to hesitate.

BUILDING UP THE WHOLE COAST REGION.

ALL the Pacific Coast needs to increase in prosperity, population, production and industry, is to make its resources known to all the world in the right way. The Pacific Coast will increase vastly within the next decade, and within a few decades will surely outstrip the Atlantic Coast in everything that goes to make up modern business and civilization. Doubtless in the Pacific States region and at no distant date, the greatest Anglo-Saxon settlement that the world has ever known will have found an abiding place and scope for its indomitable energies. The supremacy of the commerce of the Pacific involves nothing detrimental to the prosperity of the Atlantic Coast, and indeed will accentuate the progress and that of the whole United States.

The way to present the resources of the Pacific Coast is to present them by absolute statements of fact, fair, just and impartial, nothing more, nothing less. This can only be accomplished through a harmonious feeling in the entire Pacific States region. Every locality must get its due and must obtain recognition from every other part of the Pacific States region. Jealous rivalry and a disposition to disparage one section of the Coast to the booming of another section would discourage capital and industries and desirable population from coming here. The "knock" travels further than the "boost". Already the Pacific States are working together.

A practical business like method of crystalizing this spirit of progressiveness upon the Coast has been proposed. Throughout the Pacific States region there exists commercial bodies of loyal men who are intent upon developing their own locality and helping along the general movement for the welfare of all. It has been suggested, and the movement is now under way, to crystalize this sentiment of unanimity through an alliance of the Pacific States commercial organizations, so that the commercial bodies which are doing work for immigration, publicity and development, may all unite in a general Pacific States region, form a central organization of all the commercial bodies of that state, and these states in turn form a Pacific States Association.

The movement, which is now rapidly nearing consumation, will mean a great deal for the Pacific States region. In all larger matters that affect the whole coast the different sections of the coast will co-operate. The organizations now existing will not be superceded in their splendid local work, but will be aided and assisted by the general organization. Every community, while doing the most efficient work for itself will profit by the help of all other communities. The officers of commercial organizations will be stimulated in their work of developing regions and commonwealths. The movement was inaugurated more that a year ago by Rufus P. Jennings, executive officer of the California Promotion Committie. The press of the Pacific Coast region has given the work its loyal support and there is but little doubt but that a year of prosperity and progress is at hand for the whole Pacific Coast region ahead and beyond anything that perhaps the most sanguine has felt that we could conservatively expect.

MR. EUGENE HOLCOMB.

THE Allis-Chalmers Company has recently appointed as manager of its newly created foreign department, Mr. Eugene Holcomb, who takes charge of all the foreign agencies and foreign selling representatives of the company. Considering the fact that this large manufacturing concern has the world for its market, and is pushing vigorously its sales in all departments, this means that Mr. Hilcomb's field of operation will be great indeed. Not only will he supervise the work of the well established European and South African offices, and all Eastern Hemisphere agencies, but he will also have direct control over the South and Central American business for the company. With the engineering possibilities and projects in South America, Mr. Holcomb is thoroughly familiar, having spent a number of years in that country.

Mr. Holcomb received his early training in the steam engine and electrical industry on the Pacific Coast and Middle West. His knowledge and experience in the engineering fields of this country, and the engineering projects he has carried through abroad, make Mr. Hilcomb a valuable acquisition to the Allis-Chalmers Company, with which he is now identified. His headquarters will be at the general offices of the company at Milwaukee, Wis.

The Truckee River General Electric Company has just installed a three thousand horsepower water wheel unit furnished by the Platt Iron Works, of Dayton, Ohio, in their new plant at Marmol, Nevada.

INDUSTRIAL

FINEST IN MACHINERY HALL.

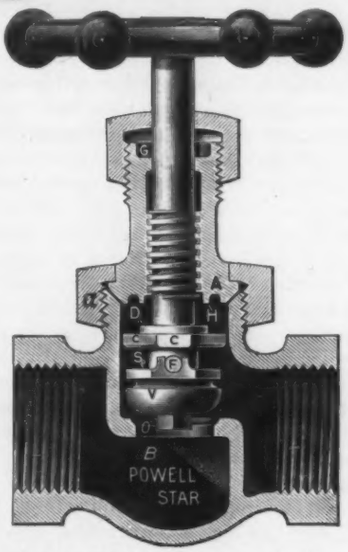
A NOTABLE feature at the Lewis and Clark Exposition, at Portland, Or., now being held, is the magnificent exhibit of the William Powell Company, of Cincinnati, of brass and iron engineering specialties, consisting of "Star" valves, lever "throttle" valves, lubricators, oiling devices, steam whistles, injectors and a general assortment of brass and nickel-plated fittings for the engine room. Especially do we note the Powell "Star" valves, a simple proposition.

There are two ways to run a plant:

First, fit it up with cheap material, then worry and spend a fortune annually in repairs.

Second, fit it up with Powell engineering specialties at a reasonable price, and thereby save for operating repairs and a nice bank account.

In the accompanying illustration we present to our readers one of the many celebrated specialties of the William Powell Company. For more than half a century the product of the Powell factories have been deservedly celebrated for superior excellence, and in one article especially the "Star" valves have attained a remarkable reputation for superiority over any and all of the diversified makes of valves for controlling the flow, especially of steam, besides other fluids, and as higher and higher steam pressure service was being demanded and adopted in all the avenues of steam engineering. The Powell Company has constantly kept in touch with the wants of the trade by increasing the efficiency of their product.



The "Star" valve, globe angle, cross or check are noted as the "regrinding" disc valve.

Special features—The bodies and working gear are made of a special valve alloy, tough, strong and durable under severe usage. The bonnet face is coned to accurately fit the body neck, secured thereto by the union nut, making an absolutely tight joint, a peculiar feature of the Powell valves.

The valve stem is made with guide wings that engage within the walls of the body neck, ensuring perfect alignment of the stem both for constant wear and for regrinding the disc to the seat when worn after long usage.

All parts are interchangeable, being made to templet gauges. All valves have a full opening throughout. All valves can be reground or discs replaced when worn out without removal from their places. They can be repaired under pressure when closed or open. All valves made with removable seats when so ordered. The lockable disc feature of the Star valve was first invented and patented by this company.

The Powell Star check valves are made exactly on the true general lines of excellency as the the globe valves, all parts made to gauge and interchangeable. The Powell valves are made screw end or with U. S. or American standard diameter and thickness of flanges. All have their patent trade mark "★" and name cast in the body and are absolutely guaranteed tested and inspected. Standard valves are for pressures up to 200 pounds, extra heavy for up to 350 pounds. The "Powell Star" valve is known throughout this country, and in foreign parts millions of them are in use—tens of thousands are in use in our war vessels and construction department of the Government, and just at this time a large contract for the "Star" valve is being executed for the Brooklyn Navy yard by the Powell Company. Engineers will make no mistake in specifying the Powell "Star" valve for exacting use.

Jobbers and dealers have the Powell catalogue and descriptive circular for the asking. Kept in stock and for sale by Baker & Hamilton, San Francisco, Cal.

THE KILBOURNE & CLARK CO.

AMONG the successful institutions interested in the commercial side of electrical engineering may be numbered the Kilbourne & Clark Co., whose headquarters are in Seattle, and who also maintain an establishment in San Francisco. C. A. Kilbourne, president and treasurer of the company, has been interested in the direction and management of electric properties in the Northwest for the past fifteen years, and Dr. E. C. Kilbourne, secretary and general manager of the company, has been well known in the electrical power field since the eighties, having been in the active management and direction of several of the power electric lighting companies of Seattle, notably the Home Electric Company, the Seattle Electric Railway Company, the Union Electric Light and Power Company, etc. Their intimate knowledge of the electric business acquired through years of experience in such work, has brought to their company a degree of success which should be gratifying to them and may well be envied by their competitors. Starting business as a supply house, dealing in supplies only, the company soon found it necessary, in response to the demands of the trade to broaden their fields of work and arrange for meeting all the requirements of the electrical industry. The result of years of successful business is evident from the magnitude of their business at the present time.

The company maintains a large establishment at 113-115 Marion Street, Seattle, where a complete stock of electrical supplies is to be found, as well as a stock of transformers, motors, generators and engines.

The company also maintains an office at 106-108 New Montgomery Street, Rialto Building, San Francisco, under the immediate management of H. G. Aylsworth, who is well and favorably known in the telephone as well as the electric light and power field.

A stock of Cooper-Hewitt mercury vapor lamps, telephones and National Electric Company's motors and Pittsburg transformers is maintained in San Francisco, and the company is prepared to fill orders promptly on anything electrical, being enabled to draw from either Seattle or San Francisco stock.

The company has the coast agency for the following well known manufacturing companies·

National Electric Company, of Milwaukee, Wis., who manufacture a complete line of alternating current and direct current generators, synchronous, induction and direct current motors and high tension transformers.

Pittsburg Transformer Company, of Pittsburg, Pa., who manufacture lighting transformers and power transformers for high tension work up to 300kilowatts capacity.

Watertown Engine Company, of Watertown, N. Y., who make a specialty of high speed automatic engines for electric lighting and power service and also build Corliss engines for electric power service.

Chicago Telephone and Supply Company, of Elkhart, Ind., manufacturers of high grade Magneto and common battery telephones, switchboards and apparatus. This company also manufacture, under license, the most modern automatic telephone system on the market.

Cooper-Hewitt Electric Company, of New York, makers of mercury vapor lamps and rectifiers.

Signalphone Company, of Milwaukee, Wis., a complete system of fire alarm, police and watchman systems.

Garton-Daniels Company, Keokuk, Iowa, lightning arresters and the "Automotneer," a device for controlling the application of power to electric cars avoiding the slipping of wheels and racking of cars and passengers caused by careless motormen.

Besides the above lines, the company is constantly adding others in an effort to keep in the front rank of dealers in steam and electrical apparatus.

Dr. E. C. Kilbourne pays particular attention to the sales of steam and electric machinery in Seattle, and E. B. Parsons is handling that end of the business in the San Francisco office.

The business of the San Francisco office has grown to such an extent as to necessitate larger quarters and new offices were opened in the Rialto Building, 106-108 New Montgomery Street, this city, on the 25th of September, where the future should bring that measure of success which is justly due such a progressive and reliable firm.

THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY AT THE LEWIS AND CLARK EXPOSITION.

THE development of apparatus for the generating, distribution, control and application of electrical power has been so rapid that engineers, station managers, power users and the engineering public in general have been compelled to keep constantly in touch with the electrical field in order to remain abreast of the times. The latest and most improved products in every line of industry may always be seen at expositions and fairs, which are great educational factors. At the Lewis and Clark Exposition, Portland, Or., in the building devoted to machinery, electricity and transportation, the Westinghouse Electric and Manufacturing Company occupies 1500 square feet of floor space. This section is devoted to the display of many kinds of generators, motors, controllers and instruments of every description.

Starting in at the main entrance to the exhibit our attention is attracted by the most prominent and most interesting feature of the display, a 400-kilowatt Westinghouse-Parsons turbo-generater unit. This outfit represents the most efficient and most economical type of apparatus which has ever been produced for transforming the energy of steam into that of the electric current. To the left is a showcase containing all the standard types of portable instruments, and just behind this is an electrically operated distant control automatic oil circuit breaker, designed to open a 200 ampere 33,000-volt circuit.

Passing on down the aisle we see a No. 92, fifty horsepower direct current and a No. 107, seventy-five horsepower alternating current series railway motor, and a switch group of the multiple control system. To the right is a group of type S motors, including a vertical type machine, a twenty-five-kilowatt rotary converter and a two-kilowatt type S generator direct connected to an Ohmen high speed engine manufactured by the Ohmen Engine Works, of San Francisco, Cal. Across the aisle is a motor generator set consisting of a 150 horsepower induction motor and a 100-kilowatt direct current engine type generator, and in immediate succession are a group of type R direct current motors, one-sixth to one horsepower, a 120-kilowatt revolving field self-contained alternating current generator, and a 100 horsepower type HF induction motor. At the extreme rear the Sanitary Devices Manufacturing Company displays in conjunction with this exhibit an automatic dust removing plant driven by a type S motor.

THE WESTINGHOUSE EXHIBIT AT THE LEWIS AND CLARK EXPOSITION

In the rear section are also some distinctive types of Westinghouse transformers, including a 110-kilowatt air blast transformer, a number of type OD, type N, manhole type. Five OD transformers, ranging from seven and one-half to twenty-five-kilowatt are mounted on the wall. On turning to the left and walking towards the main entrance may be seen a group of induction motors, types H and CCL for constant speed work, and types F and C for variable speed service. A line of special motors both alternating current and direct current for crane service is also shown. Standard switchboard instruments comprising voltmeters, wattmeters, ammeters, power factor meters, etc., are arranged on display boards against the wall. In the controller section are found an oil immersed auto-starter for use with the CCL motors, a rheostatic controller for the type HF motor, an elevator controller used with type F motors, an automatic pump controller and finally a three-wire double voltage controller for use with direct current motor in machine tool drive. Near the center of the exhibit is a rope hoist manufactured by the Denver Electric Company, to which is connected a No. 103A type F induction motor. Various classes of fuses artistically arranged on a board, a double throw oil switch, a static interrupter, choke coil and lightning arresters complete the display.

The exhibit is illuminated by two large "Westinghouse" display signs, and by series multiple arc lamps suspended from artistic goose-neck posts. It might be mentioned in this connection that the entire building is lighted by lamps of similar pattern.

DOBLE WATER WHEELS.

THE Abner Doble Company, of San Francisco, has recently received several interesting orders for Doble tangential water wheels. Prominent among them is an order from the California Gas and Electric Corporation for a 9000 horsepower wheel for its de Sabla power plant. This machine will be similar to the 8000 horsepower Doble wheel installed in the de Sabla plant last year and the three 8000 horsepower Doble wheels

recently completed and now successfully operating in the new Electra station of the same company. The wheel will operate under a head of 1530 feet at 400 revolutions per minute and will be driven by a single jet of water, thus making it the most powerful water wheel ever constructed for operation under a single jet of water. Another order from the California Gas and Electric Corporation calls for six 570 horsepower wheels for its Nevada City plant. These will operate under a 190-foot head at 410 revolutions per minute.

A 400 horsepower Doble wheel for operation under a 400-foot head, equipped with jet deflector operated by a Woodward compensating governor, and has shipped to the Chancellor Gold Mining Company, Wenatchee, Wash. The La Grande Water Storage Company, La Grande, Or., has purchased an 800 horsepower, 1150-foot head, 600 revolutions per minute Doble wheel, equipped with Doble needle regulating nozzle for operation by a Lombard governor. Among other recent orders secured by the Abner Doble Company are two double 1750 horsepower wheels for the San Joaquin Power Company, Fresno, Cal., for operation under 385-foot head; one Doble needle regulating nozzle for a large water wheel for the Komata Reefs Gold Mining Company, New Zealand, and a double 700 horsepower water wheel unit for Mitsui and Company, Japan, for operation under 210-foot head, this order including the wheel complete with Lombard governor and gate valve.

The University of Michigan has purchased the Doble tangential water wheel which the Abner Doble Company exhibited at the St. Louis World's Fair and for which the company was awarded the grand prize. This wheel is to be installed in the hydraulic laboratory of the new Engineering Building at Ann Arbor, Mich., where it will be mounted in connection with a duplex pump for experimental purposes, its output being 100 horsepower when operating under a head of 580 feet.

The twelve-inch laboratory water motors which the Abner Doble Company builds for technical schools and universities have attracted considerable attention among the engineering faculties of many of the leading educational institutions, and the interest shown in these small water wheels has resulted in an increasing demand for them, orders having recently been received from the Universlty of Wisconsin, the Michigan Schools of Mines and the University of Toronto.

SUBSTANTIAL TRANSFORMER CONTRACTS RECENTLY CLOSED.

THE new Pacific Coast Sales Organization of the Wagner Electric Manufacturing Company is demonstrating its effectiveness in the early stages of its existence. The San Francisco office, which is under the direction of A. J. Myers, has just closed a very important contract with the San Joaquin Light and Power Company, covering fifteen 100-kilowatt, 30,000-volt, self-cooling, oil filled transformers for installation at Fresno, Cal.

The northwestern organization of the Wagner Company has just closed, through the sub-office at Seattle, with the City of Seattle, for approximately $10,000 worth of small lighting and power transformers, to be employed in the enlargement of its general lighting and power service.

Both contracts are for immediate delivery, and the success of the Wagner Company in securing this business is a strong indication of the growing popularity of Wagner transformers on the Pacific Coast.

The H. W. Johns-Manville Company, 100 William Street, New York City, are sending out to their patrons a recent issue of their Electrical Catalogue, No. 14, comprising 349 pages, comprising everything electrical except dynamos and motors, many tables and specifications of great interest to engineers and contractors. Also a very complete Telegraphic Code.

EXHIBIT OF H. W. JOHNS-MANVILLE COMPANY AT STREET RAILWAY CONVENTION, PHILADELPHIA.

AS usual, the H. W. Johns-Manville Company was well represented. Their exhibit was very attractively arranged, and included a complete line of overhead line material, a number of new devices of high potential design that have recently been gotten out, a full line of "Noark" Standard and national electrical code, standard fuses, blocks, service and subway boxes and accessories, and a diversified line of moulded insulating materials, consisting of Vulcabeston, Monarch and Moulded Mica compounds. In addition to this the exhibit includes some of the well known asbestos and magnesia pipe coverings, asbestos roofing, asbestos, vulcabeston and kearsarge gaskets and packings. Among the products which attracted particular attention were transite asbestos fire proof lumber and electro-bestos fire proof insulation. The two latter materials are coming into very extensive use in the construction of electric railway cars, particularly in New York City where all the details of fire proof construction of cars have been very carefully worked out. The company distributed a very complete catalogue devoted to these materials. The line of high voltage insulators also attracted considerable attention.

The exhibit was in charge of J. W. Perry, manager of the electrical department, New York, and the following gentlemen in addition were in attendance: H. E. Manville, secretary, New York; T. T. Lyman, general sales manager, New York; D. T. Dickson, manager Philadelphia branch; H. M. Voorhis, manager electrical department, Philadelphia office; H. M. Clymer, Philadelphia office; J. E. Meek, general representative, New York, and C. N. Manfred, manager advertising department, New York.

ALLIS-CHALMERS COMPANY.

Allis-Chalmers Company has shipped to San Francisco a consignment stock of Gates Rock and Ore Breakers of various styles and sizes, together with standard repair parts which may be required for Gates Breakers which that company has already installed in various plants in California and neighboring states. It will be of interest to the customers of the Allis-Chalmers Company, who have in use any of their Gates Rock and Ore Breakers, to know that by this arrangement they will be able to secure prompt delivery of repair parts for their machines. This venture will also enable the Allis-Chalmers Company to make immediate shipment of complete crushers required in that part of the country, or in the island of the Pacific. The company's San Francisco offices are located in the Rialto Building.

A NEW PORTLAND FIRM.

E. Hippely and F. E. Myers have bought the business of the Gill Gas Engine and Machine Company, of Portland. In addition to the manufacture of gasoline engines and general machine work they will give their special attention to the installation and repair of electrical machinery. Both the gentlemen have been in the employ of the Portland General Electric Company for the past eleven years. Mr. Hippely was in charge of the steam plants and Mr. Myers, of the electrical, of the Portland General Electric Company, this dual experience serving well to fit them for their new labors which embrace both of these branches.

BAKER & HAMILTON.

The high grade line of single and four valve automatic cut-off engines built by the Russell Engine Company, of Massillon, O., are now furnished by Baker & Hamilton, who are also exclusive agents for Flory hoisting engines and Walton vertical water tube boilers, in addition to handling Jewel automatic engines and Nagle Corliss engines and return tubular boilers. This long established firm is now in position to furnish power machinery of all descriptions and to install complete power plants.

MAIN ENTRANCE EUROPEAN BUILDING, LEWIS AND CLARK EXPOSITION

WHAT ELECTRIC LIGHT HAS DONE FOR THE EXPOSITION.

IT has been well said that nothing but the modern electric light could accentuate the natural and artifical beauty of the Lewis and Clark Exposition, and high up on the list of the great and impressive features of the Fair must be accounted the lavish and artistic use of electric light.

To the visitor of the Exposition after dark the lighting of the many handsome structures in itself is an attraction, to witness which is worth a long journey. No adequate conception of the radiant splendor and rare beauty of this great enterprise enhanced by the magic of the electric light can be secured by anyone without the testimony of his own eyesight. The myriads of incandescent lamps illuminating and outlining tower and turret and minaret and dome, and accentuating the architectural beauties of the structures so artistically and effectively placed, form a marvelous twentieth-century picture.

While this is a great demonstration of the combined beauty and effective utility of electric light, it is no less a striking illustration of the absolute reliability of the service not only to the high credit of the company, but an occasion for self congratulation on the part of the citizens of Portland.

The entire complement of light and power used throughout the buildings and grounds of the Fair is furnished by the Portland General Electric Company.

A NEW TYPE OF INDUCTION MOTOR.

THE National Electric Company, builders of direct and alternating current machinery, and the Christensen air brake, so well known in the street railway field, show herewith illustrations of their new type of induction motors.

These machines are of extremely heavy and substantial construction, and they may be operated from floor, side wall or ceiling by changing brackets which carry the bearings. Owing to the high speeds at which these machines operate and the small space between stator and rotor, an extremely heavy shaft is used, while the bearings are of large area, elliminating as much as possible any variation in the air gap.

The frame is made of cast iron, into which is assembled the

1002

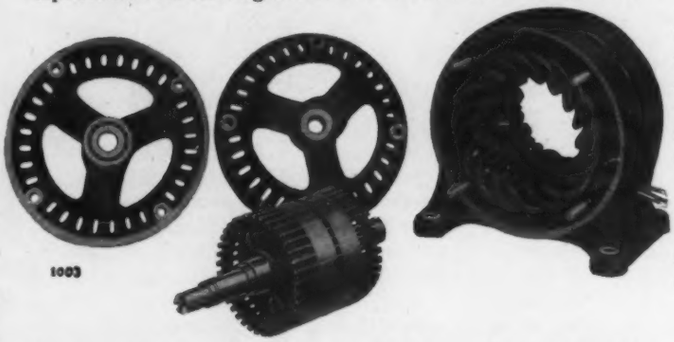
laminations. The windings are all form wound by automatic machinery and between each coil air space is provided to take care of the heating.

The ventilation has also been given careful consideration, there being numerous openings provided in the frame, and also ventilating space between the laminations.

The rotor is of the squirrel cage type with copper rods inserted in the slots. This is built up of laminations of mild steel assembled on a spider and held firmly in position by end plates.

Bearings are self oiling and have wearing surfaces of ample proportions.

An auto-starter is furnished with the squirrel cage type consisting of transformers connected across the line with voltage taps suitable for starting the motor under different conditions of



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load. A switch of suitable construction is provided for throwing the motor from one voltage to another. All of this apparatus is immersed in a tank of oil, which makes it sufficiently reliable to operate at high voltages and which takes care of any heating due to starting under heavy torque.

Bulletins and other information may be had from the National Electric Company upon request.

SOME INTERESTING OIL-FILLED TRANSFORMER HISTORY.

IN the advertising columns of this issue of THE JOURNAL the Wagner Electric Manufacturing Company calls attention to a very interesting bit of transmission history. It will be recalled that the installation of the 10,000-volt, twenty-two-mile service from the early Mill Creek power house, of the Redlands Electric Light and Power Company, to the city of Riverside was one of the pioneer Pacific Coast transmission propositions. This equipment was installed early in the year 1896 and at the time created an unusual amount of interest and attention among the electrical men, particularly in the southern part of the state.

During the intervening years there have been so many important developments in the methods of transmission and transmission apparatus that the fraternity has lost sight of this early Redlands-Riverside proposition, and it is therefore of unusual interest to have the matter again brought to attention in the way of disclosing just what the performance of the original apparatus has been.

It seems the original transformers are still in service, although they were of pioneer design, judged by the standards of today. In fact, this equipment is unique, in that it is the only installation of this particular form of transformers made by the Wagner Company. Their experience derived in this plant suggested some of the improved designs employed today.

The Riverside transmission line is one of the signal instances of complete success of a transmission proposition. The reliability of the apparatus has permitted a record of uninterrupted service, of which the engineers of the Redlands Company, the City of Redlands and the Wagner Company may be justly proud.

BYRON JACKSON MACHINE WORKS.

REFERRING to the address delivered by J. J. Brown, M. E., at the Twelfth National Irrigation Congress, held at El Paso, Tex., regarding "Turbine Pumps for Irrigation and Drainage" (copy of which appeared in the August issue of this JOURNAL), we wish to state that, with a few exceptions, the pumping plants mentioned at the bottom of column 1, page 384, to-wit: Lake Hemet Water Company, Sweetwater Dam, San Diego River Works, Redlands Water Company, Bear Valley Dam, South Riverside Land and Water Company, Gage Canal, Riverside Water Company, Union Anaheim, were manufactured and installed by the Byron Jackson Machine Works, San Francisco, Cal. This firm has been manufacturing turbine pumps for the past twenty-five years and have placed on the market pumps for both low and high pressures which have shown as good and in many instances better efficiency and durability than any other pump of this type.

250 ACRES OF CONCRETE LINING.

The concrete work on the west basin of the Jerome Park Reservoir, New York City, is nearly finished. The area of this basin is ninety-three acres, and it is being lined with concrete six inches thick, made by a battery of eighteen Ransome concrete mixers. The mixers are mounted on trucks, and are readily moved as the work progresses. The stone is delivered to the mixers in flat-cars, and is shoveled from the cars into Ransome charging hoppers.

This is probably the largest number of concrete mixers ever engaged in work at one time on a reservoir.

When the contractor, William Bradley, of New York City, has finished the west basin, he will begin upon the east basin which covers 160 acres.

THE HAWAIIAN ELECTRIC COMPANY, LTD.

HONOLULU, H. T., January 16, 1905.

Mr. Geo. E. Witt, 530 Mission St., San Francisco, Cal.

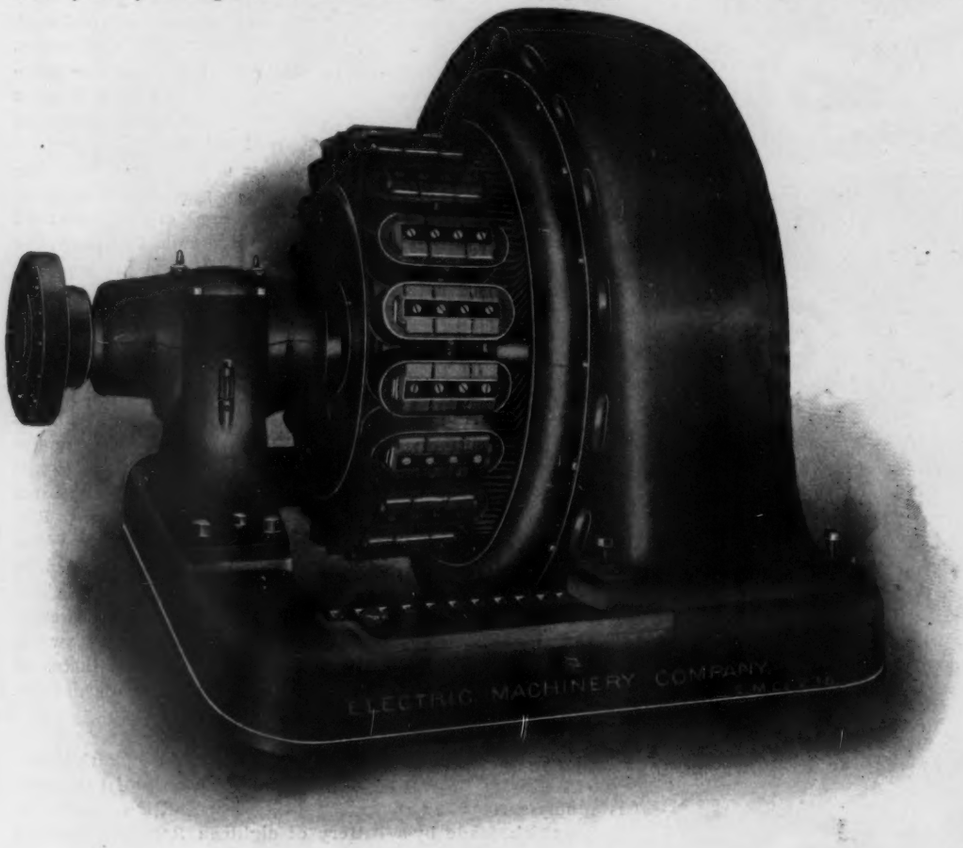
DEAR SIR: When we started to burn oil we tried a great number of burners of different makes, and after some months of experimenting adopted your incandescent burner. We now have seventeen burners in use in our power house, and they are giving good satisfaction. The oil pressure that your burners require is less than any other burner we tried, and they give very little trouble in use. We will gladly recommend them to any one wishing oil burners.

Yours truly,
THE HAWAIIAN ELECTRIC COMPANY.
O. R. WILLIAMS, Chief Engineer.

THE ELECTRIC MACHINERY COMPANY.

THE Montevideo Electric Light and Power Company, at Montevideo, Mont., are building a dam across the Minnesota River at Granite Falls, Minnesota, some twenty or thirty miles distant from Montevideo. At Granite Falls there will be installed a 400 horsepower McCormick water wheel together with a 250 kilowatt, 2300-volt, electric machinery generator, as per illustration herewith. This generator is built by the Electric Machinery Company, of Minneapolis, Minn., and is represented on the Pacific Coast by the Standard Electrical Works, at San Francisco, Cal. The generator will be direct coupled to the water wheel shaft and run at a speed of 300 revolutions per minute. This generator is of the well known revolving field type, and follows the usual designs of the Electric Machinery Company which are so well known throughout the United States.

The particular claims for merit in these machines besides high efficiency, close regulation and symmetry of design, are the exeeptionally heavy bearings, which are self oiling and self-aligning,



and the more than ordinary provisions for ventilation. As will be seen by the cut, radial holes are provided in the pole pieces, so that the air can come from the center of the revolving field directly through between the field coils and the field cores, and on out through the armature, through the ventilating apertures in same which index with those in the revolving field. The whole machine presents a robust and sturdy appearance, making it well adapted for long continuous service.

With the generators the Electric Machinery Company is also furnishing the step-up transformers which raise the voltage to 23,000 volts. At the Montevideo end of the line the company are furnishing step-down transformers and complete switchboard apparatus. The Electric Machinery Company has one of its alternators of 500-kilowatt capacity at Bemidji, Minn., which has been in operation for the past three years and is giving the best of satisfaction.

The Standard Electrical Works have already placed a number of these machines in California and the Coast, all of which are giving the best of satisfaction. This line of apparatus, while comparatively new in the West, is well established in the East, but with the untiring efforts of the local representatives it is expected that the Electric Machinery Company's apparatus will soon be as well known on the Coast as those of other manufacturers who have been longer in the local field.

MR. WALTER H. WHITESIDE AS PRESIDENT.

THE election of Mr. Walter H. Whiteside as president of the Allis-Chalmers Company, is an indication that the change in the presidency will not mean a change in the policy of the company. For Mr. Whiteside has been, during the absence in Europe since April last of his predecessor in office, in full charge of the operations of the organization with the title of vice-president and general manager.

Mr. Whiteside joined the Allis-Chalmers interests in July, 1904, when he accepted the position of general manager of sales. He came at a time when the company, which had just taken over the Bullock Electric Manufacturing Company, needed the injection of a vigorous and energetic personality into its sales force. The task with which Mr. Whiteside was confronted was one which would have baffled any man with less determination, less energy and less force of character. It was not merely that he had to become familiar with all the intricacies of the company's varied products—and they cover a larger area of human activity than that of any other great manufacturing corporation—but the new interests and the old had to be consolidated. The sales organization had to be enlarged and its efficiency increased. With what success Mr. Whiteside has met in his efforts, the increase in the volume of the company's business, and the crowded shops, and the reopening of the old South Foundry at Milwaukee can testify. In taking up this higher and more responsible position, Mr. Whiteside has behind him not only the confidence of his organization, but a long and varied business experience, in which he has filled many executive positions. His achievements have won him recognition as a man of marked administrative ability.

He enters upon his new office amid the congratulations of a very wide circle of business friends and associates.

Mr. Whiteside is a member of the American Institute of Electrical Engineers, of the Engineers' and Lawyers' Clubs, of New York, of the Mid-Day Club, Chicago, and of the Milwaukee Club.

SPOKANE, WASH.—Preliminary work for installing a $15,000 irrigation plant at Avondale will be commenced at once by the Malloy and Pohlman Company of this city. Water will be pumped from Hayden Lake by a pump with a capacity for 3,000,000 gallons every twenty-four hours.